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ORIGINAL PAPERS

DRYING PROBLEMS OF TERRA COTTA[1]

BY FRANK A. KIRKPATRICK

ABSTRACT

A description is given of the method of drying terra cotta and the results obtained at the plant of the Kansas City Terra Cotta and Faience Company of Kansas City, Mo., a plant having a production capacity of 200 to 400 tons of terra cotta per month. The drying processes are found to be governed by a plant problem and a ceramic problem. The experience obtained has led to the decision to abandon large steam-heated driers and build smaller units heated by natural gas.

I. Introduction

During the past year the Kansas City Terra Cotta and Faience Company has been working on the problem of drying, with the purpose of improving the quality and increasing the production of the ware. The experience has proven the interdependence of the plant problem and the ceramic problem of drying. The plant problem includes plant layout, construction of buildings, installment of equipment, economy in first cost, and operation. The ceramic problem is concerned with the properties and processing of the body, the physical condition of the ware, the kind of equipment, and the manner of drier operation.

The decision has been made to replace the present drier plant with a new installation which will be more economical from every viewpoint. The present and the new installations will be described, together with the methods of operation and the results obtained.

[1] Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Detroit, Mich., February, 1927. (Terra Cotta Division.)

II. Present Equipment

Building A sketch of the present drier building is given in Fig. 1. The building consists of two adjoining rooms each 30 feet wide and 50 feet long. The walls are of concrete 8 to 12 inches thick and 6 to 8 feet high. Only one wall has outside exposure. The roof

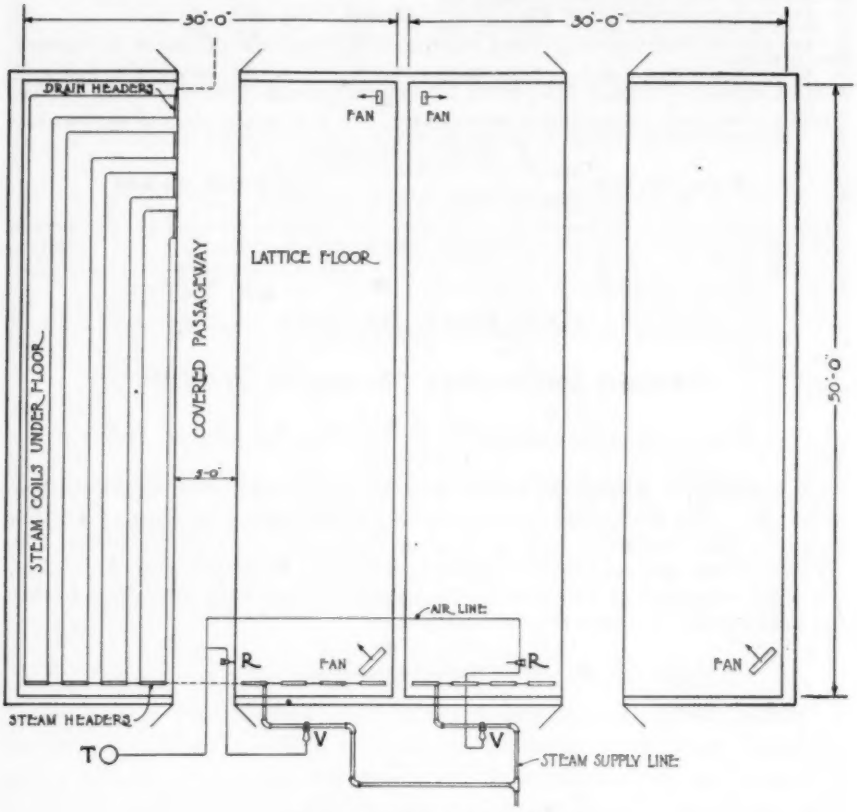

FIG. 1.—Present steam driers.

consists of a layer of one-inch boards covered with tar and gravel. Three ventilators are provided in the roof of each drier for the escape of moisture-laden air. Each room holds twenty tons of dry terra cotta.

Storage and Handling Storage space for both wet ware and dry ware is limited, and the ware could not be handled without the use of movable racks. The racks serve the double purpose of storage shelves and conveyers. The pressers turn their ware out of

The writer wishes at this point to acknowledge his indebtedness to A. H. Sheffield who kindly permitted the presentation of the data and information contained in this paper.

the molds onto wooden pallets on the floor. The pallets with ware are placed on racks which stand along a central traffic-way. The large ware is placed on low wooden racks. The small ware is placed on steel racks 4 ft. 9 in. high, 4 ft. 6 in. long, and 2 ft. 10 in. wide, constructed so as to carry ware of different sizes. The racks are taken by lift-truck into the driers and remain there until the ware is dry. They are then moved into the spraying room. The ware is taken off by the spraying crew and the racks returned to the pressing shop.

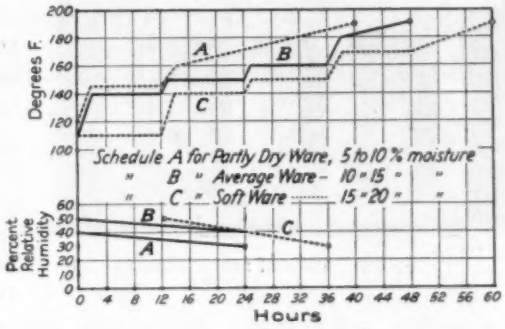

FIG. 2.—Temperature and humidity schedules.

Heat Supply and Control Steam heat is supplied by a 50 h.p. boiler located 300 feet from the driers. About one-half of the steam generated is available for heating the driers. The steam coils of $1\frac{1}{4}$-inch pipe are located beneath the latticed floor of the driers. Each drier has 3,000 feet of pipe. Condensation water is removed by outside drains and by a steam trap. High pressure steam is used. There are no low pressure coils. The steam pressure at the driers ranges from ten pounds at the beginning of a run to eighty at the finish.

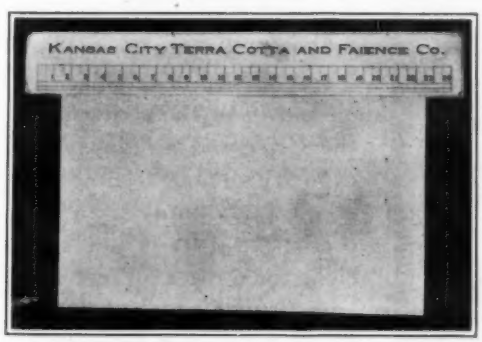

FIG. 3.—View of ashlar piece.

The coils are laid lengthwise the driers, the individual pipes varying from 35 to 60 feet in length. The coils radiate more heat at the supply end than at the drainage end, causing the temperature of the drier atmosphere to be from 10 to 30° low at the drainage end. The coils should have been placed crosswise the driers to give uniform heating conditions or better still in a duct along the wall, uniform heat distribution being obtained by ample circulation of air.

Heating of the driers is regulated by means of automatic control of the steam supply. Compressed air from a small storage tank, *T*

(Fig. 1) passes through a regulator, *R*, located inside the drier, then into a direct-action diaphragm valve, *V*, located on the steam supply line. A metallic element in the regulator expands and contracts with changes of temperature, opening and closing an air passage. When air passes through the regulator into the top of the steam diaphragm valve, the valve partially closes depending upon the amount of pressure. The regulator is adjusted to correspond to the temperature desired, and the steam valve opens and closes automatically to maintain the temperature. The control equipment has been in use since December 12, 1926. It has prevented a great deal of irregularity in heating, and has saved much of the operator's time.

FIG. 4.—View of ashlar piece.

Circulation of Air On account of incorrect design of the steam coils, the driers have a cold end and a hot end. If the usual duct system were used, in which air is blown across the drier, the hot and cold condition would not be altered. Hence no ducts are used. In one corner of the hot end of each drier is located a 30-inch disk fan. By this means hot air is blown to the cool end of the drier. The fan has a capacity of 3,000 cubic feet of air per minute at a low pressure. This is not sufficient for a drier 50 feet long and 30 feet wide. In order to decrease the amount of condensation and dripping, small fans are located at the cool end of the drier.

FIG. 5.—View of ashlar piece.

FIG. 6.—View of dentil piece.

Control of Humidity For increasing the moisture content of the air in the driers, steam is furnished by means of

openings in a half-inch pipe at the fans. The steam supply is controlled manually by means of a valve. The wet and dry bulb thermometer is used for determining the amount of humidity. An important precaution in using this thermometer is to change the wick often. If the wick is changed once a month, there will be no danger of the indicated relative humidity increasing to absurd amounts.

III. Operation

The schedules of temperature and relative humidity are shown in Fig. 2. Three different sets of schedules are used depending on the moisture content of the ware.

	Moisture in ware (per cent)	Total time in hours	Relative humidity at start (per cent)
A	5 to 10	40	40
B	10 to 15	48	50
C	15 to 20	60	Room

The moisture content refers to average-sized ware. The larger ware must have not over three-fourths the moisture content indicated above to be dried safely.

The comparatively long time required for a drier run is due to the following conditions:

1. Large and small ware are loaded together. The small ware dries in 18 to 30 hours, but the large ware requires a longer time.

2. Production schedules cause the driers to be overloaded. Heat supply and air circulation are insufficient to care for the overload.

3. The ware must be dried to a moisture content of 1%. Any higher amount causes variations in the color of some of the glazes.

FIG. 7.—View of dentil piece.

The first twelve hours of drying are the most important. Most of the cracking of ware occurs during this period. The temperature (140 to 145°F), and the relative humidity (40 to 50%) represent the average conditions for safe drying of the ware, as determined by many production runs. Lower temperatures do not give a sufficiently high rate of drying to save much time. The humidity schedules are planned to protect the ware from surface-drying and to avoid condensation of moisture on the ware. Since the amount of humidity in the air is controlled by manual manipulation, the operation

must be watched carefully. Wet ware causes higher humidity and requires less steam from the jet, than does the drier ware. Heating of the drier is regulated by the automatic steam-supply control, the temperature being "stepped up" as desired. The fans are used during the entire run of schedules A and B. In the use of schedule C for wet ware, the fans are not run during the first 12 hours, because of the possibility of surface-drying.

IV. Conditions and Results

Commercial Drying In the commercial drying of clay ware, the operations are carried on by observing the amount of defective ware, and making remedial changes in the methods. The changes are more likely to be in the right direction if fundamental laws are applied to the solution of the problem.

Fig. 8.—View of dentil piece.

The physical laws which govern the processes involved in drying are given in textbooks and are essential to a complete understanding of the delicately balanced system, clay-water-atmosphere, upon which we operate in drying clay ware.

The plant man may care more for results than for laws, and his idea of the process is about as follows: Heat warms the ware and the atmosphere causing the water to evaporate; circulation of air distributes the heat and carries the water away; humidity protects the ware from surface-drying and permits a higher initial temperature. In order that the process may be carried out efficiently there must be provided a heat supply above actual needs, vigorous circulation of air, and sufficient means of humidifying the air.

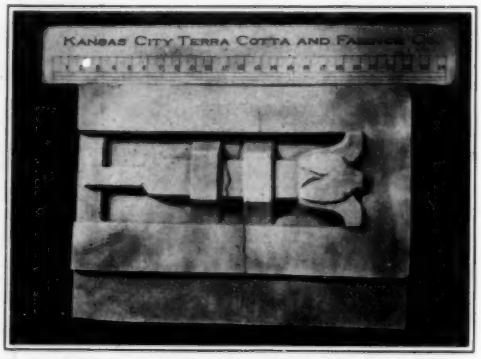

Fig. 9.—View of ornamental piece.

Heat is the prime mover in the drying process. Circulation and humidity are able aids of heat. Circulation produces a uniform distribution of the heat and the humidity throughout the drier. Hu-

midity permits a higher initial temperature of the air and prevents surface-drying.

Body Properties Body properties constitute a major factor in the drying behavior of terra cotta. The clays must have sufficient strength and bonding power. The grog must be of sufficient hardness and proper size of grain. The body proportions should be such as to produce a sturdy body.

The composition of the body is as follows:

Material	Per cent by weight
Calhoun, Mo. Clay	55
Carrollton, Ill. Clay	11
Stoneware Grog	30
Fireclay Grog	4
Barium Carbonate	0.5

The Calhoun clay contains 45 to 50% of quartz sand of which more than one-half is coarser than 200-mesh size. The clay is plastic enough to be used alone if desired. The Carrollton clay is not sandy, and is quite plastic. The stoneware grog is vitrified and hard. The fireclay grog is softer and has 10% absorption. The grog is fairly coarse, being prepared by passing over a 5-mesh screen with openings 0.167 inch.

When pressed, the body has 20% water and 80% solids. The drying shrinkage is 5% and the modulus of rupture 320 pounds per square inch. In the preparation of the body the clays are not weathered nor is the body aged.

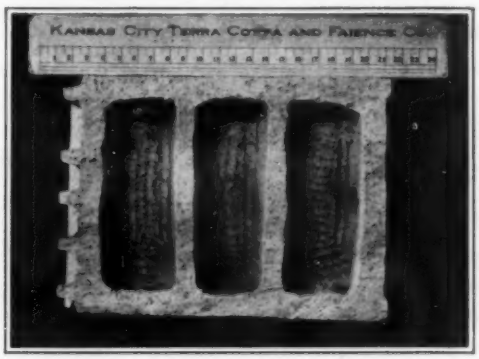

FIG. 10.—View of ornamental piece.

It is necessary to be very cautious in making body changes with the intention of improving drying qualities. For several months the amount of Carrollton clay was increased to 23% to increase the strength of the body during the drying process. The strength was increased somewhat but the plastic clay slowed up the drying. The amount of plastic clay was reduced to 11%, the methods of drying were improved, and the results of the drying process were more satisfactory.

Predrying The pressing shop is heated by steam but is not provided with equipment for forced circulation of air. The ware hence does not dry in the shop as much as it should, and some of it comes into the driers too wet. In a drier charge some ware is wet

and soft, some is partly dry and hard, hence the driers must be operated to dry the soft ware.

Large-sized ware is left in the shop until it is leather-hard and the moisture content is about 12%. This method was adopted after severe losses had occurred due to placing large-sized ware in the driers when soft and having as high as 18% moisture. Some of this ware was so soft that the webs had to be supported by clay bats. Such pieces dried unevenly and cracked through the center. Large pieces crack more often through the center than elsewhere. Any plan whereby the center portion of a piece can be dried more rapidly is a valuable aid to safe drying. Some companies use the method of blowing warm air onto the ware while it is being pressed. The inside of the piece and the webs thus dry more rapidly, and the danger of cracking is decreased.

FIG. 11.—View of ornamental piece.

The necessity of proper conditioning of the ware preliminary to rapid drying should be strongly emphasized in developing methods of drying. The rate of heating should be slow in the early stages of any method, followed by a more rapid rate for final drying. We sometimes expect too much of plastic clay, forgetting that it is a delicate material to dry.

Position of Ware on Pallets

Practically all of the ware is dried with the open side next to the pallet. The ware is turned out of the mold by the presser onto a pallet where it rests with open side down, and remains in this position until it is dried and glazed. This method has the advantage that the ware can be moved anywhere desired as soon as it comes from the mold. It is not necessary to wait several days to turn the piece upon side or end to move it. There are some exceptions, such as large ashlar pieces. To prevent cracking, these must be turned up on the side before they are placed in the drier. It is true that terra cotta will dry more quickly if set in such a manner that the webs are exposed to the air, but it is a question whether it comes through the process more safely. The act of turning the ware up on side or end is liable to cause chipping, warp-

FIG. 12.—View of ornamental piece.

ing, and cracking, unless unusual care is exercised. The pallets should be more open than those generally used. For this purpose light-weight metal pallets are more satisfactory and durable than wood pallets.

Covering of Ware All large pieces of ware are covered with burlap when placed on racks in the pressing shop. Large sill, coping and ashlar, and similar pieces are covered on the ends only. Other kinds are covered completely. The covering retards the drying, especially on the edges and reduces the danger of cracking. The burlap is removed from the large-sized ware when the drying is about two thirds complete to permit rapid final drying. Ware less than 12 to 15 inches in the longest dimension is not covered, except that on the top pallet of a rack. The top ware is subject to a more severe condition of heat and circulation than is the rest of the ware.

FIG. 12*a*.—View of ware in pressing shop.

Shape, Profile, and Size of Ware Since most of our ware is dried with the open side next to the pallet, the shape, profile, and size have a decided effect upon the drying behavior. The outward appearance of a piece is sometimes deceiving as to its profile, and the latter must be considered in studying the problem. Photographs of several pieces of ware are given to show the shape and profile. Dried pieces were used for face and back views. For the profiles, wet pieces were cut with a wire.

In Figs. 3, 4, and 5 are shown views of an ashlar which has cracked through the center. The ashlar is a difficult piece to dry in the horizontal position, as the partitions delay the drying in the center of the piece. If heated too rapidly, the piece dries in all portions except the center, and cracks in the transverse direction. The larger the piece and the more webs in it, the greater is the danger of cracking. For safe drying in the horizontal position the ashlar must be sufficiently predried and must be heated slowly enough to allow the center part to dry at nearly the same rate as the outer portions. It is observed in the photographs that the presser failed to punch holes in the side of the piece between the webs to aid the escape of moisture.

In Figs. 6, 7, and 8 are shown views of a dentil piece. This particular piece did not crack in drying, but dentils occasionally do crack on account of their irregular cross-section. In the back view it is noted that the presser did not scrape out clay to give a thinner section. The two outer dentils were cut somewhat by the punch in cutting holes in the side walls. No matter what the other considerations, the dentil piece dries more safely if some clay is scraped out of the back of the dentils. The profile, from a different piece, shows the dentils partly scraped out. This kind of ware should be carefully predried, especially the larger pieces, which are very liable to crack if placed in the drier when too soft.

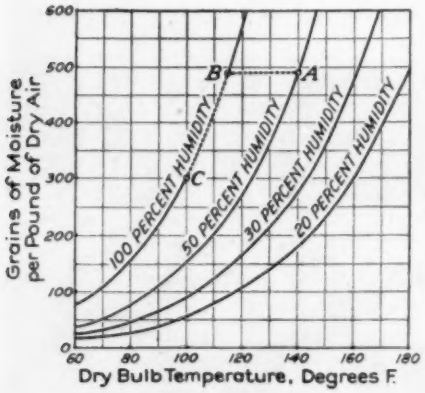

FIG. 13.—Psychrometric chart.

In Figs. 9, 10, 11, and 12 are shown photographs of an ornamental spandrel piece which was found impossible to dry in the horizontal position without a large loss from cracking. The piece shown in the photograph cracked entirely through at the center. The two profiles, one transverse and one longitudinal, show the thickness and the variability of the sections. In the transverse profile we discover a defect of pressing. The clay at the right side is scraped out so that only one-half inch of stock is left at one section. Another pressing defect is shown in the back view. There are no holes punched in the side walls between the partitions. This was a partial cause of the cracking. As in the ashlar piece, moisture could not get out of the center part except through the walls. After about 75 of these pieces had cracked it was decided to let them harden in the shop, and stand them on end in the driers for final drying. By this method 700 of the pieces were dried safely.

There are many other kinds of large sized pieces of terra cotta which are difficult to dry. In Fig. 12*a* are shown views of ware in the pressing shop; dentil, coping, and panel pieces; cornice and bracket pieces; finials and other irregular-shaped pieces. Ware of this kind is left in the shop until it is hard and contains not over 10% moisture. It is then covered with burlap and dried in 60 hours in the drier.

The size of piece determines to a great extent the method of operation of the drier and the degree of safety of drying. In general, large pieces are more subject to cracking than are small pieces. Small coping and

sill pieces never crack; small ashlars sometimes do. The ashlar is weaker mechanically than the others. All small running pieces dry safely on account of their shape. They have strong walls on three sides in the transverse direction. Large running pieces with two transverse webs dry less safely because the webs delay evaporation.

The uneven profile of a piece of terra cotta causes weakness of structure where the wall changes from thick to thin. The larger the piece the more trouble is experienced from this condition. Drying can be

FIG. 14.—Experimental gas-fired drier.

accomplished more safely and rapidly if the ware is separated into groups as to shape, size, and moisture content.

Overloading of Driers Overloading causes much more delay and loss than is generally realized. Other conditions are often blamed for losses due to overloading. The racks of ware are crowded together so that circulation of air through them is almost nil. As a result some of the ware is only partly dry when the temperature is raised to a higher degree, and cracks on account of the rapid heating.

Overloading increases the total time of drying a drier charge of ware. The present driers of this Company hold 25 tons of terra cotta in racks when crowded to capacity, but the total time of drying such a charge

is 60 to 72 hours for average ware. By decreasing the load to 20 tons and distributing the racks uniformly, the total time of drying was reduced to 48 hours (schedule B).

Condensation of Moisture on Ware

The use of humidified air in driers is a fundamental improvement, but one which introduces the destructive agency of condensation under certain conditions. The process of condensation consists of the deposition of moisture from the air onto the ware, walls, and ceiling. It occurs when the objects are at a temperature lower than the wet-bulb temperature of the air.

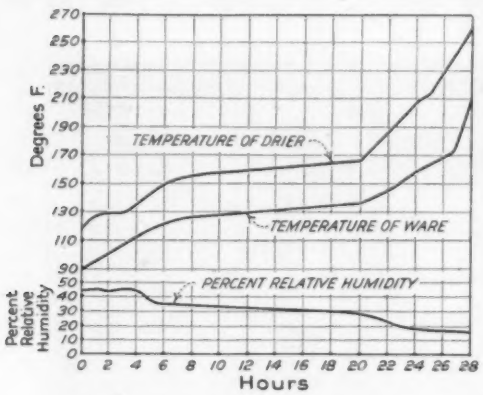

FIG. 15.—Experimental drier run.

It has often been observed that ware increases in weight by taking up moisture from the air during the first few hours of operation of a humidity drier. A film of water is often observed on the ware. Sometimes enough collects to cause disintegration of the surface. Cool ware placed in a strong current of air from a fan takes up moisture to about the same degree as if in a location of little circulation, until such time as the temperature of the ware increases to the wet-bulb temperature of the air, when the film of moisture evaporates. Circulation of air decreases the amount of condensation by heating the ware more rapidly to the wet-bulb temperature.

We have weighed ware of different moisture contents from 10 to 20% and find that all the pieces take up moisture. Ware partly dry is able to absorb moisture into its pores and into the clay grains. The moisture cannot be seen and the ware does not crack from that cause. Wet ware is unable to take moisture into its body, and the moisture collects on the surface. The result is a series of surface cracks generally parallel to each other and sometimes following laminations of the body. Sometimes enough water collects to cause deep cracks in the body.

As an experiment a soft 25-pound ashlar at a temperature of 67°F was placed in a drier whose atmosphere was at a temperature of 140°F and a relative humidity of 40%. The ashlar absorbed one ounce of water during the first 1½ hours. This was observed as a film on the surface of the ashlar. At the third hour the temperature of the ashlar reached the wet-bulb temperature of the air and the moisture evaporated. When the ashlar was entirely dry the surface was found to contain

many small cracks, the result of the condensation of one ounce of water. Small cracks are worse than large ones in this respect, that they cannot be patched, while the large cracks can be patched.

A soft 40-pound ashlar at a temperature of 80°F was placed in a drier whose atmosphere was at 146°F dry-bulb and 121°F wet-bulb, the relative humidity being 47%. The ashlar was placed directly in

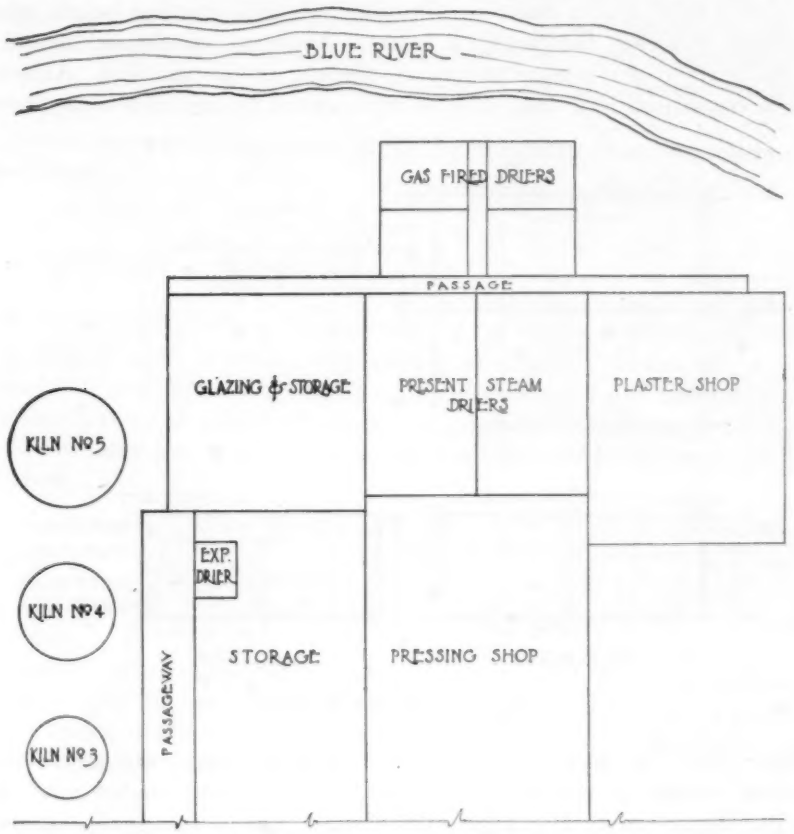

FIG. 16.—Partial plant layout.

front of the large disk fan. Water collected at once on the surface. In one hour the temperature of the ashlar had increased sufficiently to cause evaporation of the surface water. The piece was then stood on end and dried in 24 hours without cracking. The surface was pitted but no cracks were found.

The same sort of experiment was made in a drier at the highest heat. A soft 15-pound ashlar at 80°F was placed in a drier where the dry-bulb

temperature was 196°F and the wet-bulb temperature 130°F, the relative humidity being 19%. Water collected on the surface at once but evaporated in one hour. The piece was then placed in another drier in front of the fan and stood on end. It dried in 18 hours without cracking. The surface was pitted but no cracks were observed.

On one occasion five tons of cool wet ware were placed in a drier to complete a charge. The drier atmosphere was brought to a temperature of 140°F and a relative humidity of 50% in two hours, and changed little for the next 12 hours. Moisture condensed heavily on the surface of the ware and every piece in the lot cracked. Atmospheric conditions in a drier may be represented by means of a psychro-

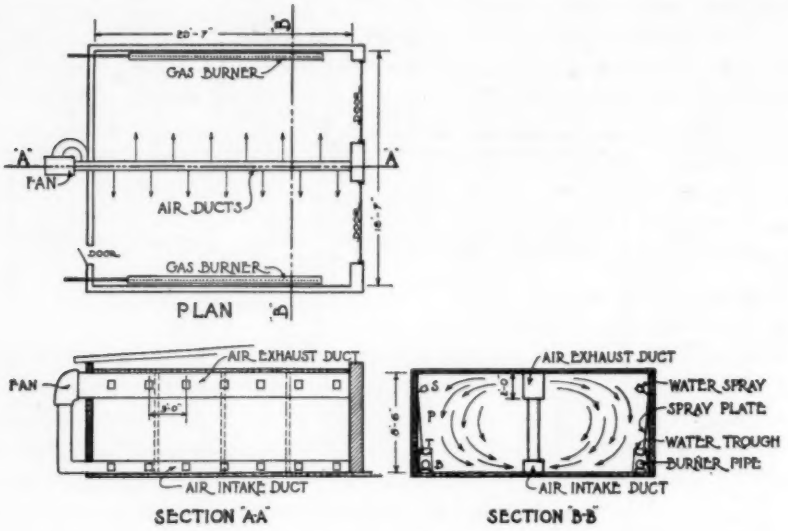

FIG. 17.—Plans of new drier unit.

metric chart, as shown in Fig. 13. A complete chart represents numerical values of the several properties of moisture-laden air. In the incomplete chart, Fig. 13, the dry-bulb temperatures are represented as increasing to the right. The actual amount of moisture in the air is represented as increasing in the vertical direction. The curved lines represent the percentage of relative humidity. The changing conditions of the atmosphere in the drier may be represented by lines on the chart.

In operating the driers, the temperature is brought to 140°F and the humidity to 50% soon after the drier is loaded. This atmospheric condition is represented on the chart by point *A*. When the atmosphere comes into contact with cool ware, the temperature of the portion in

contact decreases, with no change in actual moisture content. At the condition of point *B* (temperature 115°F) the portion is saturated. This is the wet-bulb temperature observed at the time. If the ware is at a temperature of 100°F the condition of the portion changes along *BC* to that represented by the point *C*, during which change moisture is deposited on the ware. The ware must be at or above 115°F when the steam jets are opened, to insure absence of condensation. Other conditions may be determined from the chart. If, for example, the drier atmosphere should be at a temperature of 120°F and a humidity of 30%, the ware would have to be at 80°F or more to prevent condensation.

To summarize, damage from condensation depends on the following conditions

1. Temperature of drier atmosphere.
2. Relative humidity of drier atmosphere.
3. Temperature of ware.
4. Moisture content of ware.
5. Rate of circulation of air in drier.

To avoid condensation the ware should be kept warm from the time it is pressed until it enters the drier; it should not be too soft when placed in the drier; the amount of humidity should not be excessive; circulation of air should be vigorous; the steam jets should not be opened until the ware has reached the same temperature as the wet-bulb in the drier.

Loss of Ware in Drying

During the past year, replacements due to cracking of ware in the drying process have amounted to 2% of the ware dried. This percentage will be decreased by the use of the new driers and by closer supervision and better trained workmen.

Cracking is the main defect. It is due to a combination of conditions, but mostly to the heating of soft ware too rapidly. Very little warping occurs and it is due mostly to crooked pallets. There is very little loss from causes other than cracking.

V. New Installation

Experimental

The present steam driers have proved to be unsatisfactory in many respects. A new installation has been designed, the rooms of which will be heated by direct fire, using natural gas as the fuel.

A small gas-fired drier was built, having brick walls and a pyrobar roof. A view of the drier is shown in Fig. 14. The room is 9 ft. 6 in. wide, 11 ft. long, and 7 ft. high, and holds about two tons of ware. Circulation is provided by a blower at the back, which takes air from the bottom and blows it out at the top over the ware. Heat is furnished

by natural gas burned by means of Surface Combustion Company low pressure inspirator sets. In this equipment gas from the supply line flows into a governor where it is reduced to atmospheric pressure. Air from a blower flows into a venturi throat, setting up an inspiration effect whereby a valve is opened on the governor and a controlled amount of gas is injected into the air current. The air and gas are mixed in the expansion cone of the venturi, and delivered to the air pressure head for delivery to the burner. A small section of the burner pipe is visible in the lower left corner of the photograph. The pipe is equipped with McKee blast steel tips with movable rings, each tip being drilled with twelve No. 47 Morse twist drills.

By this equipment gas and air are premixed under pressure to form a combustible mixture which burns without taking oxygen from the drier atmosphere. The products of combustion, mostly carbon dioxide and water, mix with the air circulating in the drier. The water vapor is not sufficient to humidify the air. Additional vapor is supplied by evaporation from an iron trough located over the burners.

At the time the photograph was taken the drier was loaded with kiln slabs, which are being made at the plant. These heavy slabs are being dried in 60 hours from a moisture content of 12 or 15% to the bone-dry condition. The manufacturer from whom slabs were formerly obtained stated that three weeks were required to dry them.

Several runs have been made in this drier, one of which will be described. In Fig. 15 are shown the temperature of the drier atmosphere, temperature of the ware, and the per cent relative humidity during the run. The charge consisted of 12 leather-hard sills $8\frac{1}{2}$ by 11 by 18 inches, 40 soft ashlars 14 by 18 inches, and 6 soft ashlars 19 by 24 inches. The 12 sills and the 40 smaller ashlars dried in 28 hours without cracking. They were pieces which remain in the steam driers from 48 to 60 hours for drying. The 6 large ashlars cracked beyond repair, and were not entirely dry. Observation showed that the cracking occurred before the 20th hour, at which time the temperature had reached 166°F.

At the 28th hour the temperature had reached 260°F. At this temperature the heat supply is sufficient to remove final traces of moisture rapidly, a condition not possible in steam driers. The temperature of the ware was determined by laying a thermometer on top of an ashlar. During the first $1\frac{1}{2}$ hours the temperature of the ware was lower than the wet-bulb temperature of the air and slight condensation occurred, but did not cause surface-cracking.

New Production Driers

The effect of the plant problem on the drying problem is well shown by the planning of the new installation. The sketch in Fig. 16 shows

part of the plant layout. The driers had to be planned to stand on a plot of ground between the present building line and the Blue River, hence the size and arrangement were governed partly by this fact. The size of unit is governed by the cost of the roofing. Trusses cost too much and were not permitted. Hence it was planned to build a unit 9 ft. 6 in. wide and 21 ft. long, to hold eight racks of ware. This made the cost of the equipment too high per unit of drier and it was decided to double the size and place posts in the center, still avoiding trusses. The new installation will consist of four units holding 16 racks each (about 8 tons of dry terra cotta). Since the time of drying will be cut in half, the new installation will have the same drying capacity as the old.

The construction problem demands small units. The ceramic problem is hence made easier by the provision of a unit in which more uniform atmospheric conditions can be maintained and which permits separation of the ware into groups according to shape, size, and moisture content.

In Fig. 17 are shown the plans for one of the new units. The room will be 18 ft. 7 in. wide, 20 ft. 7 in. long, and 8 ft. 6 in. high, inside dimensions. Air ducts extend through the center of the room, intake on the floor and exhaust next the roof. A blower of 1600 cu. ft. capacity per minute will provide circulation of air. Heat will be supplied by natural gas, burned in the same manner as in the small drier shown in Fig. 14. Humidity will be furnished by means of a water spray, *S*, which sprays water onto a galvanized iron plate, *P*. The excess water falls into a steel trough, *T*, which is directly over the gas burners. The water evaporates as it passes over the plate and the excess evaporates from the trough.

From results in the experimental drier, the gas is expected to cost one dollar per ton of terra cotta. The total cost of drying will be less than one-half that of the cost in the present driers.

It is admitted that a properly designed steam plant would operate at less cost than our present old and poorly designed installation. But as natural gas is available at an average cost of 50 cents per 1000 cu. ft., the gas-fired driers will operate at much less cost than the steam driers.

Summary

1. Commercial drying of terra cotta can be improved by the application of fundamental laws to the problem.

2. The body must be of the proper materials, proportions, and strength to withstand rapid drying.

3. Proper conditioning of the ware before it is subjected to rapid drying is essential for economical operation.

4. To permit prompt removal of ware from the pressing shop, most of the ware is placed with the open side next the pallet and remains in this position until dried and glazed.

5. The shape, profile, and size of the ware must be observed carefully and the ware separated into groups for drying.

6. Overloading of driers causes more delay and loss than is generally realized.

7. Condensation of moisture on the ware is avoided by heating the ware to the wet bulb temperature of the drier atmosphere before increasing the humidity.

8. The loss from cracked ware for a period of one year was 2%. Cracking is the main defect. There is very little warping.

9. Gas-fired driers of smaller size will replace the steam driers. The cost of drying will be cut in half. The time of drying is decreased considerably on account of the higher temperatures obtained with gas.

10. The smaller unit permits separation of the ware into groups according to size, shape, and moisture content, to aid in more rapid drying.

KANSAS CITY TERRA COTTA AND FAIENCE CO.
KANSAS CITY, MO.

FLASHING AND OTHER UNIQUE DEVELOPMENTS IN CONNECTION WITH A MODERN TUNNEL KILN FACE BRICK PLANT[1]

By J. T. Robson and F. M. Hartford

ABSTRACT

A few of the salient features uncommon in ordinary face brick plant design are brought out. Many of these are rendered necessary by the use of a tunnel kiln for firing. Details of plant layout, screen arrangement, method of introducing barium carbonate to the pug mill, the drier which is a combination of the waste heat and radiated heat types, and kiln design and operation are given.

Introduction

The purpose of this paper is not to describe in detail the face brick plant of the Michigan Clay Products Corporation at Williamston, Michigan, as this has already been done.[2] The idea is simply to bring out a few of the salient features which are uncommon in ordinary face brick plant design and many of which are rendered necessary by the use of a tunnel kiln for firing.

Plant Layout

A sketch of the plan of this plant is shown (Fig. 1) in order to bring out the routing, storage, etc., that are essential in providing continuity and constant supplying of material for the tunnel kiln.

A one-half cubic yard electric shovel loads the shale into cars of one and one-fourth cubic yard capacity. These are hauled to the plant either by a gasoline locomotive or an electric cable hoist. The cars

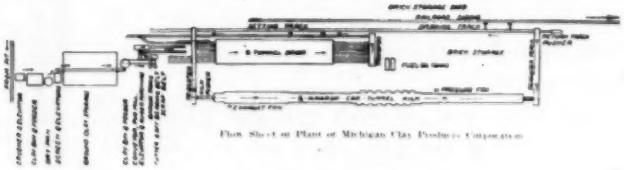

FIG. 1.

dump directly into the crusher and the crushed material is elevated to a brick walled storage bin of about ninety tons capacity. From here it is fed by a reciprocating feeder to a ten-foot dry pan, elevated to a vibrating screen and the fines are again elevated to a 101-foot belt conveyer, which runs through the top of a 2000-ton ground clay storage building. This conveyer discharges the clay where desired in

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (Heavy Clay Products Division.) Received February 24, 1927.

[2] *The Clay-Worker*, **86**, 373–79 (1926), *Brick and Clay Rec.*, **69**, 810–16 (1926).

the storage bin by the use of four ordinary plows located at equal intervals along the belt or it can discharge directly into the pug mill feeding bin.

To convey the clay from the ground storage to the pug mill feeding hopper, an underground conveyer, together with an elevator, is used. This pug mill feeding hopper is made of steel and has a capacity of 150 tons of ground clay. The hopper feeds on to a disk conveyer, which discharges on to an inclined conveyer belt to the pug mill. Here barium carbonate is introduced, the arrangement of which will be described later.

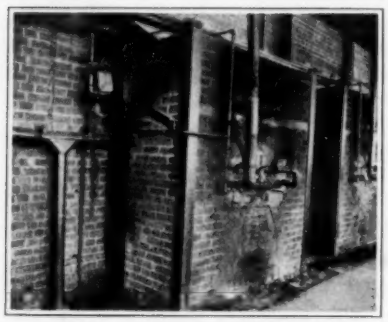

FIG. 2.

The pug mill is on the floor level, together with the brick machine. The pugged clay is conveyed to the auger by a short drag plate conveyer set at an angle of about 28°. Suspended on trusses above the brick machine is a 4000-gallon steel tank which furnishes water for the entire plant.

The brick are hacked onto double deck drier cars, each car holding 720 bricks. These cars are conveyed across the kiln car transfer track by means of a hand operated, high deck transfer car. This is rendered necessary, since the plant floor level and kiln car top level are the same, in order to facilitate setting and drawing.

From the drier, which will be described later, the cars are transferred to the setting track, where they are set onto the kiln cars.

The loaded kiln cars are then transferred to the tunnel kiln and from the kiln they are transferred over to the unloading track where they are pushed by a hydraulic ram which pushes them one car length at a time.

FIG. 3.

According to this arrangement of the kiln, drier, and tracks, the flow of kiln cars is continuous, as shown in Fig. 1.

Tex Rope drives are used on nine of the fourteen motors in operation. Figure 9 shows this drive on the brick machine.

Screen

In the grinding room the screen arrangement is rather unusual. Figure 3 shows the screen between the ground clay elevator and the

screened clay elevator, which are located in front of the dry pan. The tailings fall directly back into the pan and in case of the screen clogging it is unnecessary to leave the grinding room or to climb stairs in order to look after the screen, as is the usual case. Also, the screen is always visible to the grinding room operator.

Barium Tanks

The method of introducing barium into the pug mill is shown in Figs. 4 and 5.

In Fig. 4, a wooden tank, *A*, with 100-gallon capacity, is supplied with water from the steel reservoir tank by gravity. A float valve maintains the water at a constant level in this tank at all times, since the only purpose of *A* is to maintain a constant pressure head and hence uniform flow of water to mixing tank, *B*, of 100-gallon capacity. The use of tank *A* is rendered necessary since the height of water in the reservoir continually fluctuates.

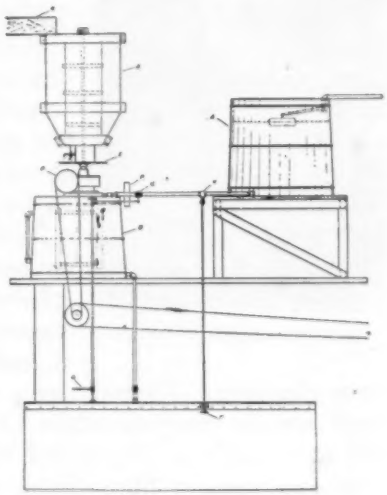

FIG. 4.

Box *C* is simply a wooden box into which is emptied the sacks of barium carbonate. This box will hold about 400 pounds of the carbonate. From here it is scraped by the pug mill man at opportune times into box *D*, which has about 700 pounds capacity. This box is provided with a 12-inch diameter disk feeder, *E*, which supplies the mixing tank *B* with the desired weight of carbonate.

In box *D* is an agitator, which is fastened to and rotated by the feeder disk. The flow of water from tank *A* to *B* is regulated by a valve, *V*, operated by the handle, *F*, which extends down to the pug mill (see Fig. 4). On the side of tank *B* is a gage glass, which shows the pug mill operator the volume in the tank at all times.

The suspended barium is fed to the pug mill through the ordinary drilled pipe, as well as through a $\frac{3}{4}$-inch rubber hose for periodic use.

In operating this mechanism, all that is necessary is for the pug mill man to pull lever *G*. This shifts the belt on to the fixed pulley *P*, which runs the feeder and agitator in box *D*, and also turns on valve V_1 which always opens wide, the flow of water being regulated by valve, *V*, as mentioned.

The agitator in tank B is run by pulley P_1 off the main line shaft. At the present time eight pounds of barium carbonate are used per thousand brick and a test of the flow of barium from the feeder each day for a period of several weeks gave no practical variation, showing that the feed is constant. Such an arrangement requires but little power, little attention, occupies a small amount of space, and gives accurate results.

Drier

The drier used at this plant is a combination of the waste heat and radiated heat type. It consists of six tunnels, each 43 inches wide by 5 feet 4 inches high and measures 142 feet in length.

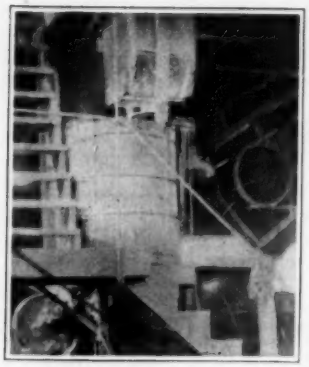

FIG. 5.

The floor proper of each tunnel is a brick and cast-iron flue, which provides heat to the tunnel by radiation. These flues are heated by coal-fired furnaces underneath, the products of combustion passing through the flues to a cross-flue and out each side in the ordinary manner to a stack.

Waste heat is taken from the kiln by means of a fan which blows it through a cross-duct to the drier. Here the air passes around the furnace walls from which it gathers heat and is discharged directly into the drier. Directly over the furnace there are two 3-inch 45° cast-iron ells, which blow the air up under the middle of the cars toward the charging end. Along the sides of the drier floor up to where the cast-iron covered flue starts, spaced every six feet alternate to one another, are these 45° ells and on the side opposite each ell is a 4-inch opening in the floor. Through these ells and openings the air is blown across and up into the tunnel proper, giving the desired circulation.

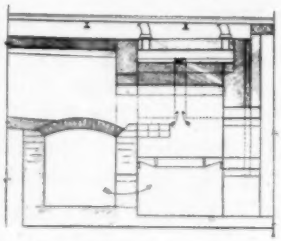

FIG. 6.

Figure 6 shows the cross-flue, together with the method of introducing the air therefrom.

Figure 7 shows a cross-section of the tunnel, illustrating the position of the openings and ells. The air travels down through the tunnel and is discharged out to the stack through an opening in the roof near the charging end.

At the present time no waste heat is obtained from the kiln, so that air at room temperature is taken in by the fan and it derives its heat only from its passage around and along the furnace and flue.

With this type of drier only clean air is admitted into the tunnel proper so that there is a prevention of any scum taking place due to sulphur gases.

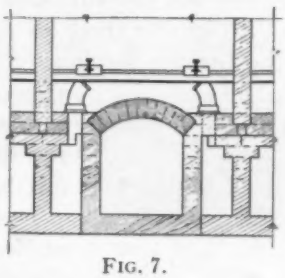

FIG. 7.

Each tunnel holds 20 cars which, with 720 bricks per car, gives a drier capacity of about 86,000 bricks per 48 hours.

The cars are pulled through the drier tunnels and out into the cooling tracks by means of a car cable puller operated by an electric motor. The cable runs under the cars and is fastened onto the last car put into the tunnel.

Kiln

The kiln is a Harrop Car Tunnel Kiln, 376 feet 6 inches long, built and designed for flashing purposes. The tunnel holds 56 cars which measure 5 feet 7½ inches wide by 6 feet 8 inches long and hold approximately 2000 brick per car, the number of brick varying slightly with the method of setting used. At the present time 38,000 brick are fired per twenty-four hours, seven days per week. This means that a car containing 2000 brick is removed from the kiln every 76 minutes and that the total firing time is about 73 hours.

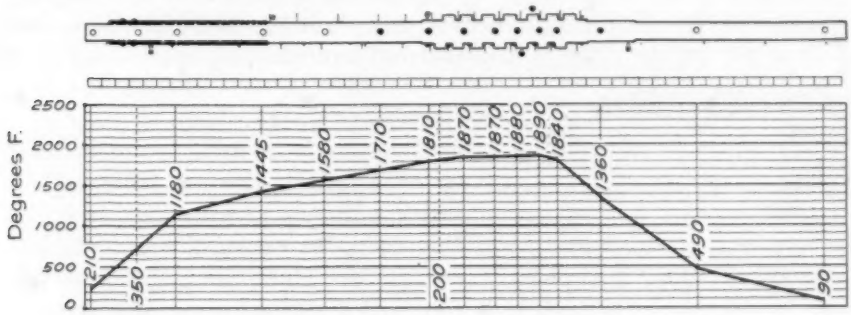

FIG. 8.

The brick are fired to a maximum temperature of 1900° according to the temperature chart shown in Fig. 8. The brick are either face set or flat set according to the type of flashed brick desired. Crude oil about 16–18° Baumé at a pressure of 35 pounds is used for fuel, together with air at 14 ounces pressure.

The ware passes up through the preheating zone of the kiln in the ordinary manner, where an oxidizing condition is maintained. It then comes into the furnace section where flashing takes place, usually in the last two furnaces on each side.

Altogether there are seven furnaces on each side of the kiln. Through the furnace section, in the crown are located four oil burners, which spray oil into the setting. Also on the sides between furnaces are located flashing burners. One of these side flashers, together with a furnace burner equipped for flashing, is shown in Fig. 2.

FIG. 9.

During flashing the air coming from the discharge end of the kiln is decreased and hot fresh air from the double crown may be introduced into the sides of the kiln just ahead of the furnaces and between furnaces Nos. 7 and 9, 11 and 13, 8 and 10, and 12 and 14.

For flashing, any one, or a combination of the top burners, together with the side burners, are used. The side burners have an air blast behind them to prevent back flashing of the gases in the kiln which are under pressure.

On slow schedule the entire last four furnaces of the kiln have been maintained under heavy reducing conditions, giving an effect similar to a strong flashing in periodic kilns. However, this method of flashing gives uniform flashed colors, which are not as desirable as the variegated colors obtained with lighter flashing, and is therefore seldom used.

The flashing is regulated to give from 30 to 70% flashed brick, depending on the market. During the months of December and January the percentage of culls obtained at this plant has been less than one-fifth of one per cent, which is considered a remarkable record.

HARROP CERAMIC SERVICE CO.
COLUMBUS, OHIO

NOTES ON FIRING IN DOWNDRAFT PERIODIC KILNS[1]

By Robert Linton

ABSTRACT

The results of a series of investigations chiefly in connection with firing are presented, with a general discussion of factors entering into the heat treatment of silicate materials. These include (1) factors controlling firing, (*a*) specific heat of the clay body, (*b*) heat of dissociation of the hydroxides, (*c*) latent heat of fusion, and (*d*) heat of reactions which take place under fusion, (2) fuel consumption and temperature rise, (3) heat distribution in the kilns, (4) firing economies, (5) cooling, and (6) dehydration and shrinkage.

Introduction

The importance of a better understanding of the structure of clay bodies and the heat conditions under which they are formed led to a series of investigations at the plants and laboratories of Pacific Clay Products, Los Angeles, California, carried out during the past two years, chiefly in connection with firing. As the Company manufactures a considerable variety of ware, including vitrified salt-glazed sewer pipe and electrical conduit, stiff-mud and dry-press face brick, enamel brick and tile, stiff-mud and hand-molded fire brick, roofing tile, drain tile, stoneware, glostware, etc., a rather unusual opportunity was afforded to compare the conditions under which these rather widely differing bodies mature. The wares are manufactured from blends of various California clays, fired in periodic kilns of the circular downdraft type with natural gas and oil as fuel.

In this paper some of the results are presented, with a general discussion of factors entering into the heat treatment of silicate materials which the investigations illustrate.

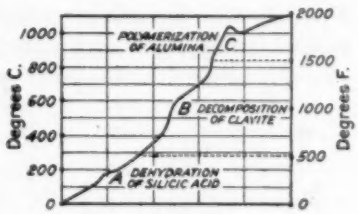

FIG. 1.—Thermochemical reactions of china clay. (J. W. Mellor)

In spite of much excellent research devoted to the subject, relatively little can be stated definitely in regard to the chemical structure of ceramic wares, and the more intimate reactions resulting from heating mixtures of silicate-forming materials are still less understood. The writer advanced some years ago the hypothesis that glass is a solid solution in an alkaline silicate of various oxides and salts; others have taken the view that it is a simple mixture of silicates with a eutectic intermediate between the lowest and highest fusibility of the silicates which may be assumed to compose it. But as yet it has not been demonstrated

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (Heavy Clay Products Division). Received February 23, 1927.

just what the chemical structure of glass really is. Clays likewise exhibit certain eccentricities when heated to incipient vitrification which cannot be explained satisfactorily except by assuming some molecular rearrangement, but just what change in chemical structure actually takes place is still largely a matter of conjecture.

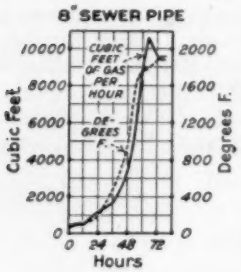

FIG. 2.

The behavior of silicates under heat involves many complex factors, both chemical and physical, and there is probably no subject so important to the ceramic industry in its whole field of research as that which has to do with a better understanding of these factors, and a more intelligent control of the conditions affecting them.

Factors Controlling Firing

Wares which are fashioned from plastic clays may be fired so as to attain their final form by (1) induration or (2) vitrification. When heat is applied to such wares, the mass first hardens, then is dehydrated, the hardness usually increasing progressively with the dehydration. Shrinkage takes place in two stages, (1) with expulsion of the mechanically combined water, and (2) after dehydration is complete when the fusible constituents soften, flow together around the less fusible aggregates, with contraction of the mass.

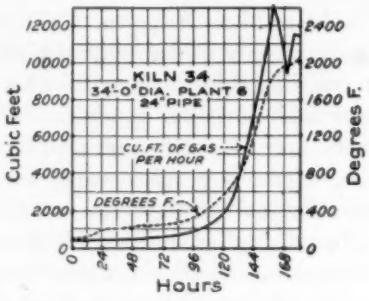

FIG. 3.

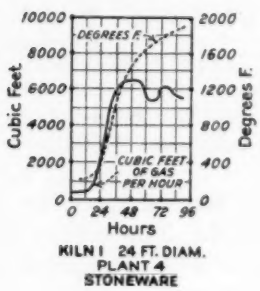

FIG. 4.

Indurated bodies, such as high heat firebrick, are composed of nonplastic aggregates cemented by hardened, dehydrated, and slightly sintered plastic clay. They are porous and of comparatively weak structure. Vitrified bodies, such as sewer pipe and stoneware, are formed by complete inclusion of the aggregates in a softened matrix. They are dense and strong. Silicate mixtures such as clay bodies and glass do not have definite melting points, but soften gradually under application of heat. There is usually a considerable range of temperatures between the point of incipient fusion and softening to complete deformation. The vitrification range is an important factor in firing.

Firing clay wares is influenced by the following heat factors:

1. Specific heat of the clay body
2. Heat of dissociation of the hydroxides
3. Latent heat of fusion
4. Heat of reactions which take place under fusion

The first three are endothermic, the last may be either endothermic or exothermic. In clay ware, even though vitrified, the degree of fusion is slight and the chemical reactions of negligible thermal effect. Where a silicate mass is brought to complete fusion, as in glass melting, definite chemical reactions are known to take place and the heat of these reactions and of fusion are more important factors. Mellor and Holdcroft[1] found that at about 1470°F* there is a change in kaolinite which renders it denser, less hygroscopic, and less soluble in acids. They estimate the heat of this reaction at 21.5 calories (exothermic). They determined the heat of dissociation of the hydroxides taking place above 932° to be 42 calories. Willi Cohn[2] found the heat of reaction of china clay at 1742° to be 16 calories, and the heat of dissociation of the hydroxides at 1067° to be 92.6 calories. By far the greater part of the heat absorbed by the clay ware being fired is utilized in raising the temperature of the bodies, and not in equalizing chemical reactions.

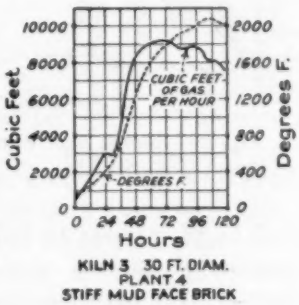

FIG. 5.

Specific heats of various wares, as determined in the Pacific Clay Products Laboratory are as follows:

Stiff-mud face brick	.272
Hand-made fire brick	.258
Dry-press face brick	.284
Sewer pipe	.246 to .289
Roofing tile	.270
Stoneware	.302

The thermal efficiency of the firing operations, that is, the quotient obtained from dividing the total heat units absorbed in heating the ware to maturity by the total heat units produced by combustion of the fuel was found to be higher than generally stated, due probably to the use of natural gas for fuel, which is better adapted to economical firing than coal. Figures for various kinds of ware are as follows:

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[1] *Trans. Ceram. Soc.* (Eng.), 1910–11.

[2] "The Problem of Heat Economy in the Ceramic Industry," *Jour. Amer. Ceram. Soc.*, **7**, 359–76, 475–88, 548–82 (1924).

* In this paper all temperatures are given in Fahrenheit degrees.

	Per cent
Stiff-mud brick	21
Dry-press brick	23
Sewer pipe	8
Unglazed stoneware	7
Glazed stoneware (including saggers)	8
Glazed stoneware (excluding saggers)	4

As compared with these figures calculations made by the writer some years ago on the thermal efficiency of glass furnaces gave 5.7% for a window glass pot furnace, 12.6% for a window glass tank furnace, 22% for a bottle tank furnace, all coal fired; and 10.9% for a plate glass furnace fired with natural gas. Better utilization of heat in ceramic furnaces and kilns is an inviting field for research.

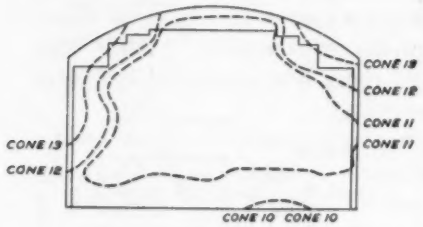

FIG. 6.—Normal heat distribution of 30-foot face brick kiln.

Fuel Consumption and Temperature Rise

With the above figures in mind it will be of interest to follow the heat development through the firing period, of various ware, and ascertain if possible the relationship between the acceleration of fuel consumption and rate of temperature rise. Obviously the ware will be brought to maturing temperature as rapidly as possible, that is, the firing period will be made as short as possible. The proper length of time is necessarily determined by experience, nevertheless, as research throws more light on the subject, it becomes clear that there is a scientific basis for much which has been worked out empirically.

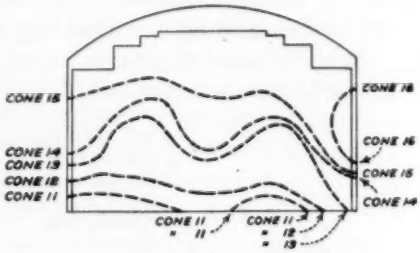

FIG. 7.—Effect of uneven draft on heat distribution in 30-foot kiln.

J. W. Mellor[1] immersed a thermocouple in dried china clay and subjected it to gradually and evenly rising temperature. He found that the thermocouple did not register a correspondingly even temperature rise, but showed acceleration or retardation of the rate of heating at several points. These he concluded were due to the chemical changes taking place in the clay substance. He summarizes the factors as follows:

[1] Journal Birmingham Metallurgical Society, 1911.

230°	Loss hygroscopic moisture
390°	Decomposition of colloidal silicic acid and other colloids
900°	Clay decomposes into free alumina, free silica, and water
1472°	Alumina polymerizes; silica alters to tridymite
2192°	Alumina and silica recombine to form sillimanite
2700°	Sinters to a stonelike mass
3002°	Clay softens and loses its shape
3092°	Brown viscid fluid

Mellor's curve illustrating these changes is shown in Fig. 1.

In practice what is desired is an *evenly* accelerated temperature rise in the clay mass itself. It will be obvious that, in consequence of the chemical changes noted and their thermal effects, this can only be obtained by a variable rate of fuel consumption. Consequently while the pyrometer chart of a kiln should show a consistent curve of heat development, fuel consumption may vary quite irregularly, due both to the thermal reactions of the clay bodies, and by meteorological conditions as well.

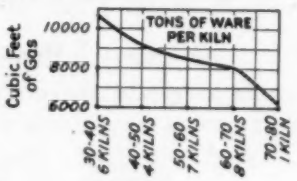

FIG. 8.

Figures 2 to 5 are heat and fuel consumption curves of actual firings of several different classes of clay ware. A few points will be at once observed.

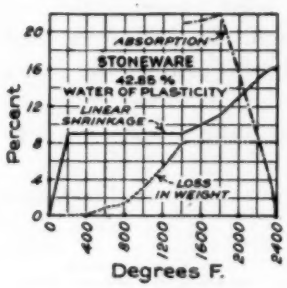

FIG. 9.

1. Fuel consumption accelerates more rapidly than temperature in the first part of the firing and lags behind temperature in the latter part. This is of course chiefly due to absorption of heat by the kiln itself until it becomes saturated, after which the rate of absorption is merely the rate of conduction through the kiln and external radiation.

2. The maximum fuel consumption takes place before the ware has reached its finishing heat. For the various products this was as follows:

	Temperature at maximum fuel consumption	Finishing temperature
Sewer pipe	1800°–1880°	1900°–2060°
Stiff-mud brick	1840°	2080°
Dry-press brick	1700°	1920°
Stoneware	1600°	1900°
Enamel brick (bisque)	1600°	2050°
Glossware	1600°	1650°

3. Watersmoking, excepting possibly in the larger sewer pipe where the body is not only thick but dense, can be carried on rapidly. Ample but not excessive air should be used, for the clays yield up their moisture readily and it is simply a matter of evaporation to carry it away. Watersmoking, heat, and time for various products are as follows:

8 in. sewer pipe	240°	24 hours
12 " " "	280°	24 "
18 " " "	350°	96 "
24 " " "	400°	106 "
Stiff-mud brick	400°	36 "
Dry-press brick	320°	60 "
Stoneware	240°	21 "

The watersmoking period is of course the critical stage of the operation. Once safely past heat may be applied as rapidly as the ware will absorb it until the maturing temperature is reached.

Heat Distribution in the Kilns

To ascertain the distribution of heat to the various parts of the kiln, cones have from time to time been placed in thirty-nine kilns firing the various ware produced by the Company. The cones were set in a cross-section of the kiln occupying a vertical plane midway between the doors and at right angles to the center line of the kiln passing through the doors. The number varied, but there were at least three horizontal rows of five cones each. Saggers were used in the sewer pipe kilns to protect the cones against the action of the salt fumes. Figure 6 is a typical chart recording a test on a kiln of face brick.

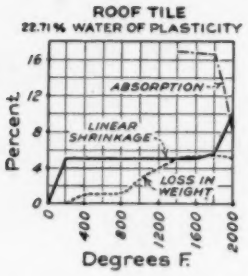

FIG. 10.

Kilns at all plants are circular downdraft kilns with ten fire boxes and draft through spoke flues radiating from a central well hole, with a separate flue underneath leading to the stack. Dimensions vary somewhat, but in all cases there is ample flue area. Of the sixty kilns operated forty-six are thirty feet in diameter, eight are thirty-four feet, and the other six twenty to twenty-four feet. Stacks vary in height from fifty to sixty-five feet. Natural gas and oil are used for fuel.

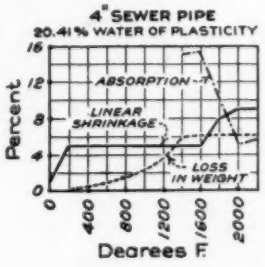

FIG. 11.

The heat was found in general to be well distributed throughout the kiln. The top averages about two cones hotter than the bottom, and the highest temperatures naturally are at the fire boxes. The clays are blended so as to provide in each case a body with maturing range of at least three cones. Some of the choicer face brick colors made by the Company have, however, a considerably shorter range, which is taken care of

by setting in certain parts of the kiln where temperature and flame conditions will be exactly what are required.

The tests further illustrated quite clearly what every experienced burner knows, *viz.*, that draft tends to pull the heat through certain parts of the loaded kiln, rather than to pull uniformly through the whole mass. Figure 7 illustrates a case of this kind, where the heat pulled down one side so as to heat the bottom three cones hotter than the bottom on the opposite side. In this case there was a range of five cones between the highest and lowest temperatures developed, which is more than most bodies can withstand. Skill and care in firing is the only sure remedy against this short-circuiting, assuming that the ware is properly set.

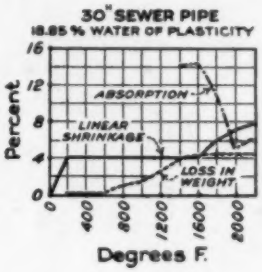

FIG. 12.

It must be borne in mind that firing ceramic ware, and especially heavy clay products is done very largely by convection. Combustion of fuel in the fire boxes gives off heat which is imparted to the waste gases of combustion and the air mixed with them. These hot gases are drawn into the kiln, surround the ware, and give off to both the ware and the walls and crown of the kiln the heat acquired in the fire boxes. The heat penetrates slowly to the center of the ware, for clay is a poor conductor of heat. The firing must be continued until the ware is fired throughout, and in doing this the kiln finally becomes so hot that a portion of its heat is radiated back to the ware being fired with a contemporaneous reduction in fuel consumption.

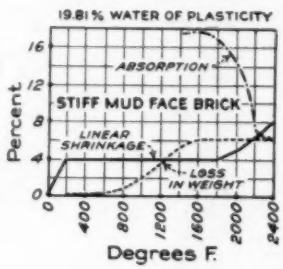

FIG. 13.

Firing Economies

It is, of course, self-evident that the greater the tonnage fired in a kiln of the same dimensions the more economical should be the operation. Figure 8 is a curve plotted from firing twenty-six kilns of salt-glazed material in thirty-foot kilns. The usual tonnage fired is from forty-five to sixty tons and within this range there is not a great deal of difference in the gas burned per ton. But the efficiency decreases below these limits, and increases above them, very rapidly.

It is further self-evident that the shorter the firing time, the more economical will be the operation. There are limits beyond which firing

cannot be speeded up with safety. Yet there is no doubt that practice has gone to the extreme in laying at the door of firing all defects, such as slabbing and warping, which develop during the firing period, and in believing that slow firing obviates them. Texture of the bodies, and flowage during processing are important factors to take into consideration in avoiding such defects.

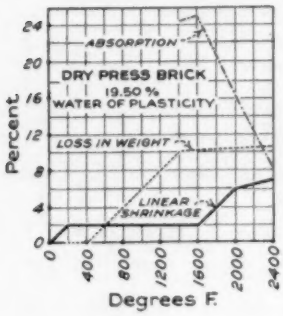

FIG. 14.

Cooling

Present practice has not only demonstrated that the firing period can be safely shortened, but that cooling can even more be speeded up. The use of fans to blow cold air into the kilns shortly after the fire is shut off is very general. Too early application of the cold blast results in damaged ware, especially where the body is vitrified, or has a glazed surface. The range of temperatures within which a vitrified body becomes brittle by rapid cooling is probably small. The writer some years ago made some studies of internal strains in window glass and found that in heating window glass cylinders preparatory to flattening them into sheets the temperatures at which they were most liable to burst lay between 800° and 1000°F. Experience in cooling sewer pipe with fans suggests that strains develop, when cooling is too rapid, around about the same heat level; but if the ware is cooled slowly down past the danger point, giving the molecules in the semi-viscous mass opportunity to adjust themselves, then no damage can result from further cooling, be it ever so rapid.

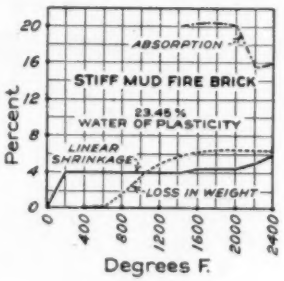

FIG. 15.

Dehydration and Shrinkage

A number of trial pieces were cut from various freshly processed wares and heated progressively at intervals of 200°F to maturity. The trial piece for each temperature was weighed, measured, and tested for porosity. Figures 9 to 15 show the results of some of these tests.

They show quite clearly that shrinkage above 200°, where the water of plasticity has been entirely expelled, is not a consequence of dehydration. In all cases excepting high heat fire brick, dehydration is entirely complete before shrinkage commences, and usually complete at least 200° below the temperature at which firing shrinkage begins.

650 CHAMBER OF COMMERCE BLDG.
LOS ANGELES, CALIF.

HYDROGEN-ION CONCENTRATION AND ELECTRICAL CONDUCTIVITY OF CLAY SLIPS[1]

I. PLANT STUDY

By A. H. Fessler and Hobart M. Kraner

ABSTRACT

The apparatus and method of determining the H-ion concentration and electrical conductivity of clay slips are described. Measurements were obtained on daily samples of tap water, casting and plastic slips, car shipments of clays, and individual blungers of slips in an endeavor to find whether any variations that might occur in the plant processes could be traced to variations in the slips indicated by these measurements. In a following paper values will be given showing the effect of temperature, time and vigor of stirring, specific gravity and concentration of various salts such as NaCl, Na_2SiO_3, $MgSO_4$ and $AlCl_3$ on the H-ion concentration, viscosity, and electrical conductivity of slips.

Introduction

The influence of effective alkalis and acids on clay or clay slips is an important factor in our present method of manufacture. The use of electrochemical methods of determining the effective acidity or alkalinity of a solution by means of H-ion concentration and conductivity is in common use in other industries.

Randolph and Donnenwirth,[2] contribute much information on H-ion concentration in connection with their work on various clays and clay slips, but our attention was given entirely to clays and slips as used in our plant processes in an effort to use these measurements as a means of slip control.

Numerous and often contradictory results are reported regarding the effects of acids and alkalis of different strengths on the physical properties of slips and clays. Evidently the action depends on many factors such as the original condition of the clay as regards its acid or alkaline content, the ratio of the clay and water, the time of aging of the mixture, the strength of the added electrolyte, etc.[3]

The determination of electrical conductivity undoubtedly could find useful application in ceramic practice, especially in the control of casting and clay slips.[4]

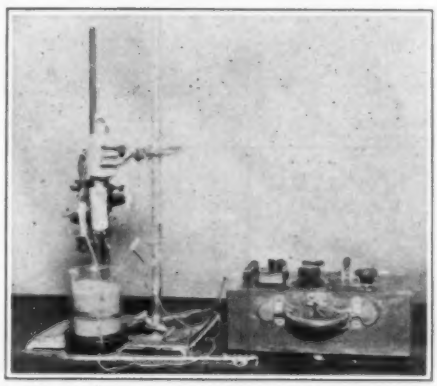

Fig. 1.

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (White Wares Division.) Received May 9, 1927.

[2] *Jour. Amer. Ceram. Soc.*, **9**, 541 (1926).

[3] Leonor Michaelis, General Principles of the Effects of Ions in Colloids, 2nd Colloid Symposium Monograph, 1925.

[4] A. V. Bleininger and C. S. Kinnison, *Trans. Amer. Ceram. Soc.*, **15**, 523 (1913).

Within certain limits the electrical conductivity is approximately proportional to the concentration of the salt. A concentrated solution may not, however, conform to simple rules. Bulletin No. 61, U. S. Department of Agriculture states that the resistance of a soil having a given salt content increases with increase in fineness and amount of organic matter.

It therefore does not seem practical to compare the electrical conductivity of one clay or clay slip with the conductivity of another clay or clay slip but the method does offer a comparison of the condition of the same clay or slip. The electrical conductivity of solutions varies with the materials, their concentration, degree of ionization, and temperature. The conductivity increases with temperature rise not because of increase of number of ions but due to their increase in speed because of reduction in internal friction.

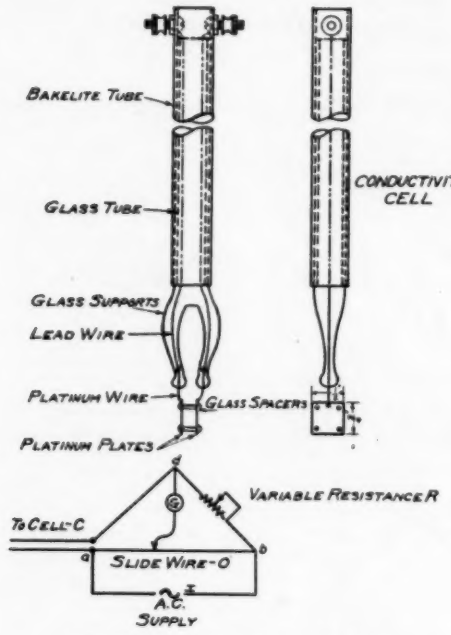

DIAGRAM OF CONDUCTIVITY CIRCUIT

FIG. 2.

Apparatus

The specific resistance of an electrolyte may be defined as the resistance in ohms of a column of solution one centimeter long and one square centimeter in cross-section. Specific conductance is the reciprocal of specific resistance. The cell used in this work is shown in Fig. 2. The dimensions are not those of a standard cell and the conductivity values given are therefore relative.

Figure 1 shows the apparatus used in this work for determining the H-ion concentration.[1] In all the data reported in this paper a quinhydrone electrode was used.[2]

Figure 3 shows the apparatus used in determining the conductivity[3] of the slips. An alternating current galvanometer with scale was used

[1] Clark, The Determination of H-ions.

[2] Kolthoff and Furman, Potentiometric Filtrations, p. 220.

[3] Washburn, The Principles of Physical Chemistry.

to determine balance of the system. The current used was 110 v. a.c. 60-cycles and the diagram used is shown in Fig. 2.

Daily Tests on Plant Slip Processes

Figure 4 (curve 1) indicates that there is considerable variation in the H-ion concentration of the tap water, plastic process, and casting slips. No apparent variations occurred in the workability of the bodies or in their drying, firing, and test behavior, as a result of these H-ion variations.

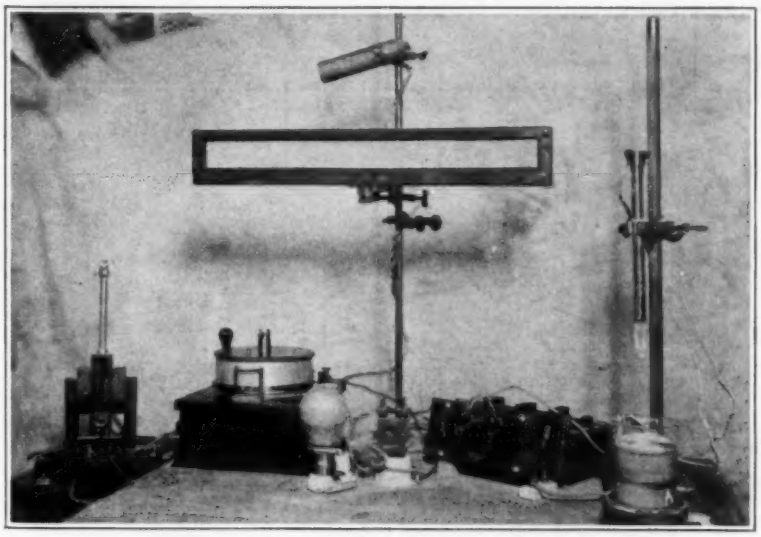

FIG. 3.

We could find no comparison between the H-ion concentration of the tap water and the viscosity of the slips. In the plastic slip the water used for blunging is obtained from the waste water of the filter presses with a small amount of fresh water added daily. In the casting slip the H-ion concentration is influenced so much by the electrolyte added that the effect of change in H-ion concentration of the water is apparently not appreciable in comparison.

H-ion Concentration on Car Shipments

Figure 5 (curve 2) indicates a large difference in H-ion concentration of the clays as shipped. By the method of clay storage used, one car load is spread out on another and the clay supply to the blungers is therefore representative of four or five cars and the H-ion concentration is probably an average of these.

The average H-ion concentration of the English china clay and the two ball clays is approximately the same. The Georgia china clay is apparently more alkaline than the ball clays.

Plastic Slips from the Blungers (Fig. 6, curve 3)

Procedure The conductivity cell was first installed in the trough from blunger to cistern but because of some collection of fibers on the plates, it was removed and the samples of slip were obtained from the trough with a sampling bottle.

A large sample was obtained so that the viscosity, specific gravity, H-ion concentration and conductivity values were all obtained on the same sample. The H-ion and conductivity values were corrected for temperature changes according to Fig. 8 (curve 5). The viscosity was obtained with a standard Mariotte tube viscosimeter.

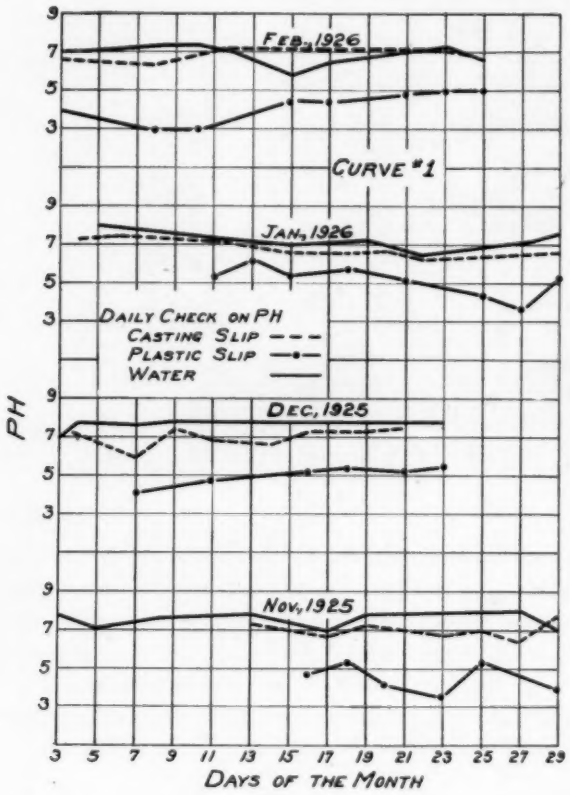

FIG. 4.

Results There is apparently no relation between any of these determinations. The H-ion concentration shows very little variation between blungers. The conductivity variation is large but this variation does not seem to affect the working properties of the resulting body.

Since the H-ion concentration and conductivity values are indications of the concentration of salts present, it would seem that the viscosity should vary with these values. Such is not the case, however. Apparently there are factors which influence the conductivity of the slips but do not affect their H-ion concentration or viscosity.

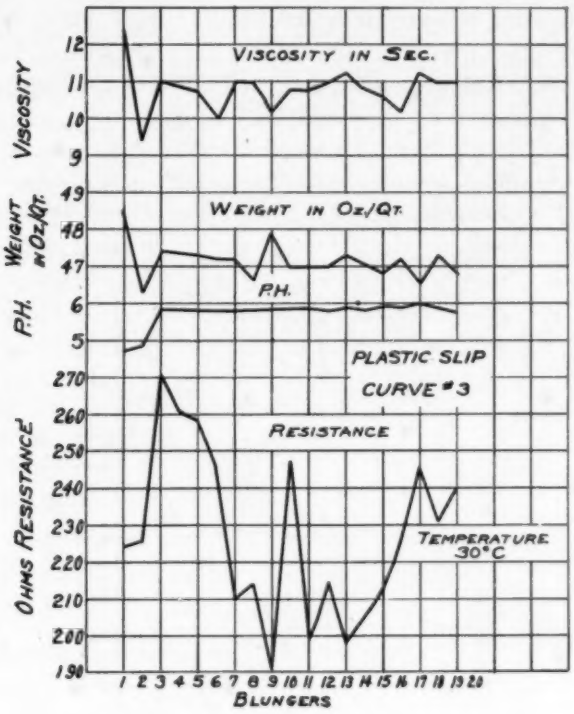
VISCOSITY IN SEC.
VISCOSITY
WEIGHT IN OZ./QT.
WEIGHT IN OZ./QT.
P.H.
P.H.
PLASTIC SLIP
CURVE #3
RESISTANCE
OHMS RESISTANCE
TEMPERATURE 30°C
BLUNGERS

FIG. 5.

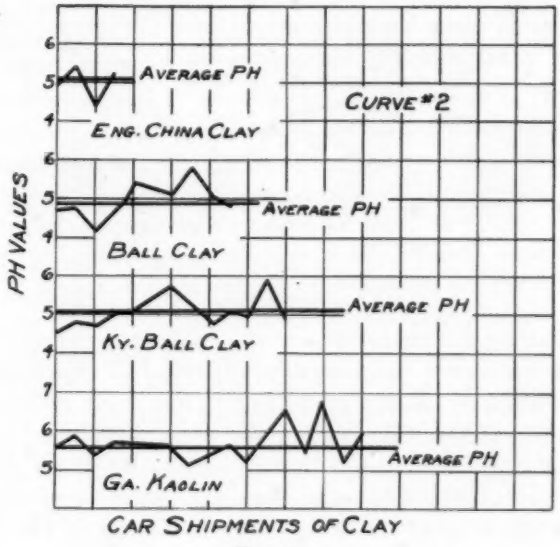
AVERAGE PH
CURVE #2
ENG. CHINA CLAY
AVERAGE PH
BALL CLAY
AVERAGE PH
KY. BALL CLAY
AVERAGE PH
GA. KAOLIN
PH VALUES
CAR SHIPMENTS OF CLAY

FIG. 6.

Casting Slips from the Ball Mills (Fig. 7, curve 4)

The procedure on the casting slip was to obtain the sample from the ball mills as they were being emptied. The H-ion and conductivity values were corrected for temperature changes.

Results Here again there is apparently no comparison in the results obtained. The changes that occur in the viscosity are not indicated by corresponding changes in the H-ion concentration or conductivity values.

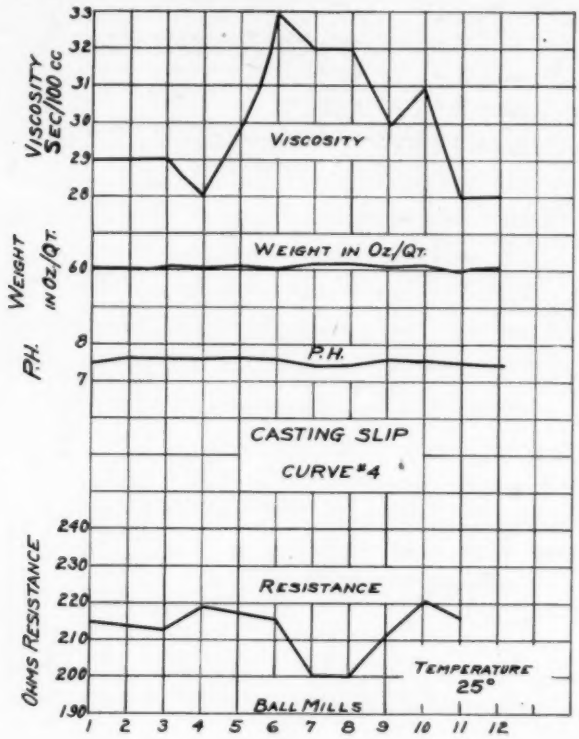

FIG. 7.

Summary

1. Measurements obtained on the daily tap water, casting and plastic slips indicated considerable variation in H-ion concentration but these differences did not result in any apparent variations found in the workability of the body made from these slips.

2. No relation could be found between the H-ion concentration of the tap water used in blunging and the viscosity of the slips.

3. Car shipments of clays showed a variation in H-ion concentration but no corresponding differences could be found in the other properties of the clays.

4. Within certain limits, changes in viscosity and density do not produce changes in conductivity of the plant slips.

Conclusions

From the results obtained it would seem that the determinations of H-ion concentration and electrical conductivity do not offer a means of plant slip control. There is apparently no consistent relation between viscosity, H-ion concentration and electrical conductivity of plant slips according to this work, and the large variations indicated by the conductivity measurements do not produce erratic behavior in the plant processes.

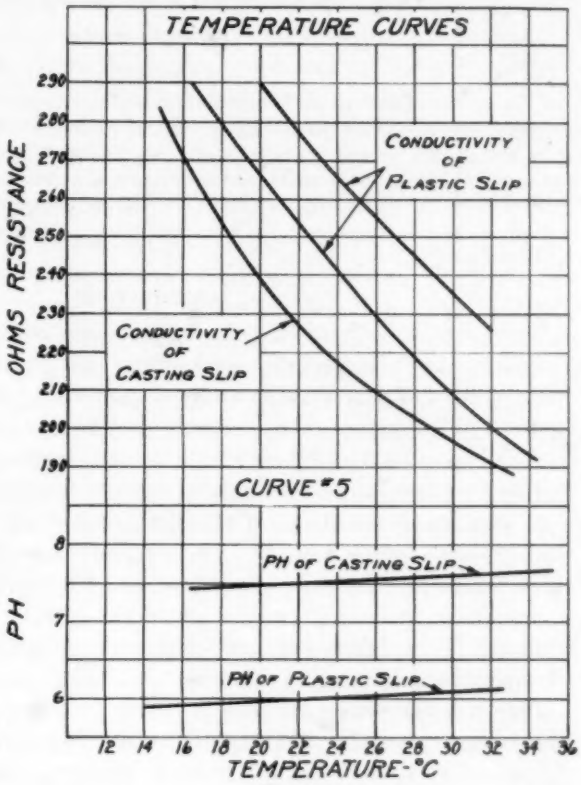

FIG. 8.

It would seem from the work so far that the H-ion concentration is not influenced as much as is the viscosity by the electrolytes present in the slips. The H-ion concentration values indicate little variation whereas electrical conductivity indicates wide variation in slip condition which is not apparent throughout the plant processes.

Therefore, it would seem that viscosity control remains the best method of plant slip control since the working properties of the clay bodies seem to be related more directly to viscosity values.

WESTINGHOUSE ELECTRIC AND MFG. CO.
EAST PITTSBURGH, PA.

STUDIES OF THE CHANGES IN THE VISCOSITY OF CLAY SLIPS AND GLAZE SUSPENSIONS ON AGING AND BY TREATMENT WITH ELECTROLYTES[1]

By James R. Bowman

ABSTRACT

The rate and extent of the spontaneous thinning out of clay slips and glaze suspensions were measured; the effects of electrolytes on the viscosities of slips and glazes after aging until minimum viscosity was reached were investigated; measurements of the rate and extent of the spontaneous thinning of a glaze after treatment with electrolytes were made; and further experiments bearing on spontaneous thinning were conducted, such as heating the slip or glaze and the application of the colorimetric method in determining p_H, etc.

Introduction

The property of clay slips and glaze suspensions, generally known as viscosity, is of considerable importance, as it affects to no small degree the stability of suspensions and the uniformity and ease of their application. With many glaze suspensions their viscosities become rapidly diminished soon after their preparation. Investigation of the problem has not proceeded far enough to determine whether all glazes undergo a reduction of viscosity on standing, but with many of them it is a well-known fact. Clay slips of relatively high concentration undergo this change in viscosity also, but not to the extent that glazes do. This action is usually spoken of as thinning. It begins immediately after the slip or glaze has been prepared and usually reaches minimum viscosity in three to five days.

This spontaneous reduction in viscosity is very troublesome at times. The coarser particles of glaze material will not remain suspended after the viscosity is reduced below some more or less definite value. Also, the uniformity of application of the glaze is interfered with.

Since viscosity is to be reckoned with in the preparation and application of slips and glazes and as it is extremely unstable in some cases, it is obviously desirable to have as clear an understanding as possible of the changes which take place and of the means of control.

During the past year the Midland Terra Cotta Company has done some work on this problem, measuring the rate and extent of the spontaneous change in the viscosity of slips and glazes; determining the effects of certain electrolytes on this action; and looking for the cause of the spontaneous change in viscosity.

For this work English ball clay was used in each case for the experiments on clay slips. Two glazes suspended with English ball clay, each of which has a strong tendency to thin out, were selected for the

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (Terra Cotta Division.)

experiments on glazes. In order to distinguish between these two glazes one of them is designated as A and the other as B.

Glaze A is partly fritted and contains in its formula English ball clay, china clay, Canadian feldspar, zinc oxide, whiting, tin oxide, red lead, flint, and rutile. Glaze B is entirely raw and contains Canadian feldspar, Wisconsin white clay, English ball clay, whiting, zinc oxide, flint, and leukonin. These slips and glazes were proportioned with water and ground in a ball mill in the usual manner.

Method Used in Determining Viscosity

The method employed for measuring viscosity was the familiar one of timing the outflow of the material from a pipette of the gravity flow type. The method of expressing values of viscosity was different from that usually practiced, in that absolute units were used, the pipette being calibrated to give values in millipoises. This method of expressing values is more advantageous than that which is usually practiced, when determinations are made with this kind of instrument and values expressed as relative to that of water. With the calibrated pipette its results can be duplicated by others of similar calibration and when absolute units are used the results obtained with different pipettes are comparable. Another important advantage of the calibrated pipette is that its loss in the midst of the work does not vitiate results as does one which gives relative values only.

The pipette is essentially a 100 cc-pipette bulb having a tube of somewhat larger bore than that of the ordinary pipette and a funnel at the top. A three-inch glass capillary, inside diameter two to three millimeters, is sealed on the bottom of the bulb. The pipette is enclosed in a water jacket consisting of an inverted five-pound bottle, the bottom of which has been cut off. The temperature of the bath may be regulated by addition of hot or cold water. This method of regulating the temperature serves the purpose very well when determinations are made with the material at about room temperature, as the writer did, but if more elevated temperatures are desired an electric heating element immersed in the bath is necessary. All determinations of the viscosities of slips and glazes made in this laboratory were at 20°C; therefore, the use of a heating device was not necessary.

Detailed description of the pipette and methods of calibration are given in a paper by M. L. Sheely.[1]

Effects of Aging on the Viscosity of Slips and Glazes

A slip was prepared consisting of one part by weight clay and two parts by weight water, and its viscosity measured immediately after

[1] *Ind. Eng. Chem.*, **15**[11], 1109 (1923).

its preparation and daily for a period of 33 days, in order to find if it would change on aging. During this time the slip was kept in a sealed vessel, to prevent loss of water by evaporation. This precaution was practiced with all of the slips and glazes used in the tests that followed.

The specific gravity of the slip, which is necessary for the calculation of viscosity, was determined by the use of a 100 cc pycnometer. The temperature of the slips and glazes at which the specific gravity determinations were made was in all cases 20°C.

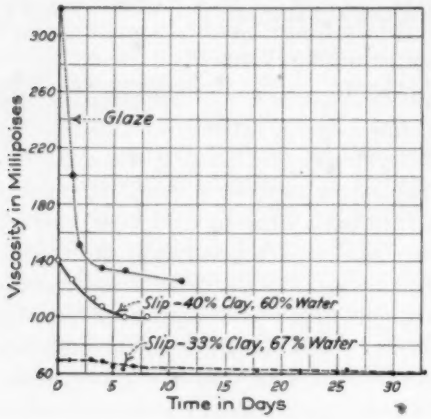

FIG. 1.—Curves showing spontaneous reduction in the viscosities of two clay slips and glaze A on aging.

The viscosity of this slip decreased slightly during the entire period of aging as shown by Fig. 1.

It then became of interest to know what the results would have been had the slip been more concentrated. For that reason another slip was prepared of one part clay and one and one-half parts water and tested daily. In this case a much greater reduction in viscosity took place and the minimum was reached in six days.

The effects of aging on the viscosity of glaze A were then studied in the same manner as that of the slips, the details of the work being the same.

There was a very rapid reduction in the viscosity of this glaze during the first two days of aging. After the second day the rate of thinning-out gradually decreased and the viscosity was found to approximate a minimum in six days.

Clay Slip Treated with Electrolytes

Samples (four hundred grams each) of the less concentrated of the English ball clay slips referred to above, which had been aged until it thinned out to approximately minimum viscosity, were treated with increasing quantities of the following electrolytes: $N/4$ acetic acid, $N/4$ potassium hydroxide, $N/4$ sodium sulphate, and finally distilled water. The purpose of the distilled water series was to determine to what extent the viscosity of the slip was lowered in each case by the water in which the electrolyte was introduced. The treated samples were well stirred, allowed to stand for about thirty minutes, and their viscosities then measured.

The data given in Fig. 2 representing the acid treated series, show that there is good reason for the practice of using acid rather than a base or salt for bringing terra cotta slips up to "gage" after they have thinned out.

The viscosity increased rapidly with the first six cubic centimeters of acid, as may be noted. Further additions of the acid caused a decrease in viscosity, but this decrease was probably due to dilution by the water of the acid solution, as indicated by the series of samples treated with water alone, which showed corresponding reductions in viscosity.

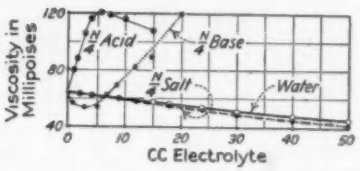

FIG. 2.—Curves showing the effects of electrolytes on the viscosity of a clay slip. To 400-gram portions of the slip were added increasing quantities of the $N/4$ solutions of acetic acid, potassium hydroxide, and sodium sulphate. To another series was added increasing quantities of distilled water.

The relatively small reduction in viscosity produced by small quantities of base do not seem consistent with the effects of bases when used in connection with the casting process. The viscosity of this slip was low to start with, however, and it is probable that this reduction would have been much greater in the case of a more concentrated slip, such as would be used in casting. Likewise, the viscosity of the slip after treatment with salt solution was not in harmony with that of a slip to which dry salt has been added. The curve representing the effects of the salt solution is in this case almost identical with that of the water-treated series, while it has been found that when dry salt is added to a slip the viscosity is materially increased from the start.

Glaze "A" Treated with Electrolytes

Glaze A was treated with increasing quantities of electrolytes after aging, in the same manner as the slip referred to above, using the same $N/4$ solutions and samples of the same weight.

The results of this test, as shown in Fig. 3, are somewhat at variance with those of the clay slip, in that the base in this case caused a decrease only in viscosity. It seems evident, however, that while the rapid drop in viscosity with the first ten cubic centimeters of the base solution was caused by the base proper, the reduction from that point on was very likely due to the thinning effect of the water of the base solution. A similar conclusion was reached concerning the descending portion of the salt solution curve.

From the appearance of the samples treated with base and salt, when more than ten cubic centimeters of these solutions were added, it seemed that flocculation had taken place, even though this was not shown by

the viscosity measurements, for in these cases there was less tendency for the coarser particles to settle out than in similar suspensions in which no electrolytes had been used.

Other samples of the glaze were then treated with double normal solutions of the base and salt, in which case less water was introduced with given amounts of these electrolytes. A very small quantity of this stronger base solution caused a slight decrease in viscosity, while larger quantities caused a rapid increase. The viscosity was moderately increased by small quantities of the salt solution, but was reduced somewhat by the water of the salt solution when larger quantities were added. These latter results while not plotted, are comparable to those obtained with another glaze and shown in Fig. 4, as solutions of the same normality were used in both cases.

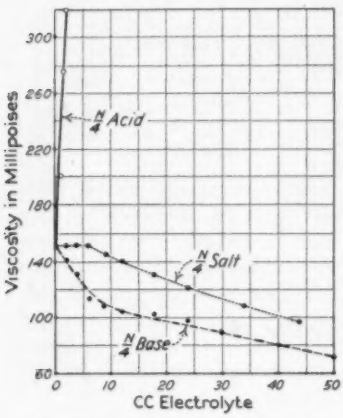

FIG. 3.—Curves showing the effects of electrolytes on the viscosity of glaze A. To 400-gram portions of the glaze were added increasing quantities of the $N/4$ solutions of acetic acid, potassium hydroxide, and sodium sulphate.

Glaze "B" Treated with Electrolytes

This raw glaze was treated after aging with increasing quantities of electrolytes, the details of which were identical with those of glaze A and the ballclay slips, previously mentioned, except that in this case double normal solutions only of the electrolytes were used and the samples were allowed to stand over night before their viscosities were measured.

Figure 4 shows that solutions of base and salt of double normal strength, as well as acid, increased the viscosity of the glaze. However, the characteristic drop in viscosity produced by a very small amount of the base was noticeable in this case, though to a lesser extent than when weaker solutions were used.

The Effects of Aging on the Viscosity of a Glaze That Has Been Treated with Electrolytes

It has been found in practice as well as in the laboratory that when the viscosity of a glaze is increased by the addition of an electrolyte, it will decrease again on aging. A test was made to determine the rate and extent of this thinning in the following way: Glaze B was aged until its viscosity had reached a minimum of 64 millipoises. It was then divided into two portions. Acid was added to one of them and base to

the other, in which case the viscosity of each portion was raised to a relatively high degree, no effort being made, however, to bring the viscosity of each portion to the same point.

The viscosity of each portion was then measured daily until it reached a minimum, which in each case required about five days. The results of this test, given in more detail in Fig. 5, indicate that the use of a base for "gaging up" glazes would not be as satisfactory as acid, because of the more rapid and extensive thinning out of the glaze after treatment with the base.

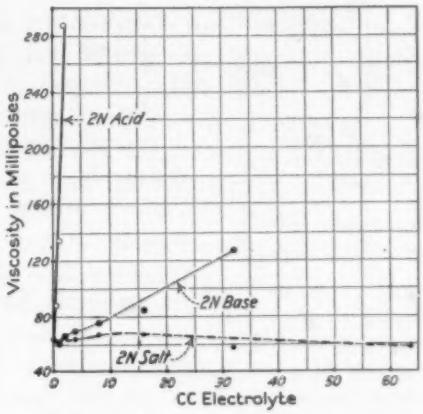

FIG. 4.—Curves showing the effects of electrolytes on the viscosity of glaze B. To 400-gram portions of the glaze were added increasing quantities of the 2*N* solutions of acetic acid, potassium hydroxide, and sodium sulphate.

It will be noted that the data for the thinning out of a glaze on aging were obtained from tests on glaze A, whereas, the data for the thinning out after aging to minimum viscosity and then bringing up the viscosity again by means of an electrolyte are from tests on glaze B. Obviously data from both the first and second agings of the same glaze would have given a more satisfactory comparison, but were not available at the time of the preparation of this report.

It is indicated by the viscosity curves for the first and second agings that if the first aging is allowed to proceed for only a limited time, say 12 hours, and then an electrolyte is added, thinning will take place more rapidly than it would if the glaze had been aged to minimum viscosity. No tests have been made to confirm this conclusion, but it is supported by experience in the factory.

Further Experiments Bearing on Spontaneous Thinning Out

A number of experiments were conducted with a view to arriving at a better understanding of the spontaneous thinning out of slips and glazes. These experiments are briefly described as follows:

Experiment No. 1 Distilled water instead of tap water was used in the preparation of a ballclay slip and also in glaze A, and the viscosities measured daily. The use of distilled water for this purpose was to eliminate any possible action of dissolved substances in the tap water, which might influence thinning. If the constituents

of the tap water were in any way responsible for thinning, that fact would probably be revealed. The results showed similar reductions in viscosity to those of the same slip and glaze when tap water is used in their preparation.

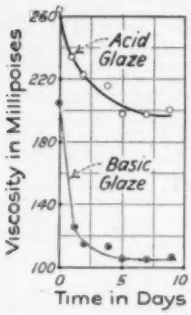

FIG. 5.—Curves showing the rate and extent of the thinning out of glaze B after it had been aged to minimum viscosity and then its viscosity increased again by means of an acid and a base.

Experiment No. 2 Glaze A and a ballclay slip, each of relatively high viscosity when first prepared, were heated to boiling, cooled to 20°C, and the effects of the heating on their viscosities noted.

Heating seemed to cause immediate reduction in viscosity in both cases. However, this was not definitely confirmed in this particular case, for the viscosities of the slip and glaze were not measured prior to the heating. The test was then repeated with the slip and its viscosity measured immediately before and after the application of heat. In this case the viscosity was reduced by heating, from 216 to 95 millipoises. The viscosities of the two slips and the glaze which were heated, were then measured daily and found to remain constant.

This test showed, at least in the case of the slip, that heating hastens the action of thinning and causes its completion at once, whereas, at room temperature it takes place more slowly requiring in most cases a number of days for completion.

Experiment No. 3 A slip of ball clay was heated to boiling, in order to bring its viscosity to a minimum at once, cooled to room temperature, and then used as a suspending medium for glaze A. Except for this difference the glaze was prepared in the usual way.

The viscosity of the glaze was then measured daily to find if the clay, which had been heated and its tendency to thin thus destroyed, would influence the tendency of the glaze to thin. The results of this test showed that the glaze thinned on aging, the viscosity being reduced from 217 to 107 millipoises.

Experiment No. 4 Throughout these experiments it was found that in every case where a small quantity of base was added to either a clay slip or a glaze suspension the viscosity of these materials was reduced and reached a minimum with very small quantities of the base. This information is not new, however, and is probably well known in general practice. At any rate, it became of interest to know the effects, if any, on the viscosity of a slip when in the course of its preparation a sufficient quantity of a base is added to produce mini-

mum viscosity. A slip of ball clay was therefore prepared by adding to the requisite quantities of clay and water the calculated amount of KOH to induce minimum viscosity and then grinding in a ball mill. The slip was then aged and its viscosity measured daily. The result was a reduction in viscosity similar to that of the untreated slips heretofore mentioned.

Experiment No. 5 Tests were made to determine whether there is any relation between the spontaneous thinning of clay slips and glaze suspensions and their hydrogen-ion concentrations, as indicated by the colorimetric method. The investigation was later extended to include the relation between viscosity and hydrogen-ion concentration of slips and glazes treated with electrolytes.

It is held by workers in the field of colloids, that correct measurements of hydrogen-ion concentration by the colorimetric method cannot be made in the presence of clay substance, because of the adsorption of hydrogen ions as well as of the coloring ingredients of the indicators by the clay substance. It was thought, however, that the indications of hydrogen-ion concentration obtained by the colorimetric method might at least serve to show the trend of any relation which might exist between hydrogen-ion concentration and viscosity.

This method was accordingly applied to both slips and glazes on aging and the results correlated with viscosity determinations made at the same time. These slips and glazes were later treated with increasing quantities of certain electrolytes and the colorimetric method applied in each case.

The results of these tests failed to show any consistent relation between the hydrogen-ion concentration, indicated colorimetrically, and viscosity. In the cases of the slips and glazes that were aged, the viscosity became decidedly reduced, while the hydrogen-ion concentration appeared to remain constant. The viscosity was increased by additions of acid and the hydrogen-ion concentration likewise appeared to increase; while in the case of base treated slips and glazes the viscosity was increased and the hydrogen-ion concentration appeared to decrease.

Conclusions

The data presented in this report showed that a glaze when allowed to stand after preparation without the addition of any electrolyte, underwent a very rapid drop in viscosity during the first two days, after which there was a further but much slower reduction in viscosity, which became very slow after six days of aging. A clay slip of low viscosity showed a slight reduction of viscosity extending over a period of 33 days, while a clay slip of higher viscosity showed considerable

reduction in viscosity which terminated after six days. It was also found that this spontaneous thinning was greatly accelerated and its completion brought about at once by heating the slip or glaze. The curve for the spontaneous change in viscosity of the glazes indicates that if this glaze were to be used within two days after being made up, it would tend to give trouble in application.

The results of further experiments showed that a glaze that had stood until the spontaneous reduction of viscosity was complete, responded with a rapid straight line rise in viscosity when treated with small quantities of acid, whereas, a 2 *N* solution of a base produced a slight reduction in viscosity followed by a relatively slow viscosity increase. The viscosity was increased by a 2 *N* solution of a salt, but the increase was less than that produced by the base.

The results of other tests showed that glaze suspensions which were aged until the thinning out was complete and then the viscosity brought back with an electrolyte, thinned out more slowly and to a less extent than they did in the initial aging. Also the viscosity reduction in the acid treated sample was smaller and less rapid than that of the sample which was treated with a base.

No tests were made on the behavior of glaze suspensions treated with electrolytes after only partial thinning out. From the foregoing data it would appear, that there are at least two available methods for improving the behavior of such glazes in practice, namely: (1) the glaze may be heated and its thinning out thus completed at once, after which the viscosity can be brought up to "gage" by the addition of an electrolyte, or, (2) the glaze can be made up several days in advance of its use and then treated with an electrolyte. The merits of this second method have been confirmed by results obtained in our factory practice.

The further studies reported while throwing some additional light on the spontaneous change in the viscosity of slips and glazes have not led to positive conclusions. It seems to be a reasonable assumption, however, that the reduction of viscosity is due to deflocculation of materials of the slip or glaze present in the flocculated state and that it is influenced by the presence of electrolytes. The basic cause of this deflocculation is, therefore, probably the same for both slips and glazes.

No consistent relation between viscosity and hydrogen-ion concentration was indicated by the colorimetric method.

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THE EFFECT OF MILL PRACTICE ON THE WORKING PROPERTIES AND FINISH OF VITREOUS ENAMELS

By J. E. Hansen

ABSTRACT

Variations in mill or grinding practice are shown to affect the working properties and finish of vitreous enamels. Uniform mill practice from day to day is necessary for exact color matches from day to day in some shades of enamels. Too small a mill charge contaminates the enamel with abraded pebble and mill lining material, and may therefore decrease the gloss and alter the color. Attention is called to the possibility of obtaining too much "set-up" in an enamel charge ground in a new or newly relined pebble mill. The particle fineness of the enamel may be tested by the usual screen test, or in a cone screen, which is described.

Introduction

The Report of the Enamel Division's Committee on Standards for 1925–26 in its section on Factory Control Tests[1] reveals that some sort of control of the grinding of enamels is carried out in almost every enameling plant. The writer, however, has come into contact with several cases of enamel difficulty where the trouble was caused not so much by lack of control of the grinding operation, as by the wrong kind of grinding or mill practice. A brief description of these difficulties, and how they were eliminated, together with other general observations on how grinding practice may affect the working properties and finish of the enamel forms the basis of this paper.

Previous Studies

R. D. Cooke[2] has studied the effect of variation of the speed of rotation of the mill, proportion of water to total charge, size of the charge, quantity of pebbles, and the ratio of size of charge to the quantity of pebbles, with respect to the power and milling time required per one thousand pounds of enamel, but he does not report what effect (if any) these variations had on the quality of the enamel.

R. L. Cawood[3] discusses the use of pebble mills for grinding glazes and enamels from an economic and physical equipment standpoint, but makes no mention of the quality of the enamel produced.

E. W. Lawler[4] discusses the details of design of pebble mills, the lining, the balls, and the loading of a mill, but also makes no mention of how exception to his recommended practice may affect the enamel.

B. T. Sweely and E. S. Prince[5] have studied the relation of fineness of grinding to opacity in white enamels applied by dipping, finding

[1] *Bull. Amer. Ceram. Soc.*, **5**, 241–51 (1926).
[2] *Ceram. Ind.*, **6**, 183–84 (1926).
[3] *Ibid.*, **7**, 254–55 (1926).
[4] *Jour. Amer. Ceram. Soc.*, **8**, 853–57 (1925).
[5] *Ibid.*, **5**, 855–57 (1922).

that maximum opacity was developed with fine grinding and lessened opacity with coarse grinding. With their enamel, keeping in mind both the dipping qualities and the opacity, best results were obtained when the glass was milled to a fineness such that all would pass 100-mesh, and from 5 to 10% would be retained on 120-mesh.

Reasons for Coarse Grinding

It is a rather generally recognized fact that the fineness of grinding of the enamel has much to do with the ease with which this enamel may be worked in the shop. Enamel which is too finely ground does not handle well at the dipping tank, that is, it usually does not flow or drain evenly, and is, to use a shop term, too "short."

Likewise, enamel which is very finely ground cannot safely be dried swiftly with artificial heat (rather than natural drying) for drying cracks will form, and the enamel will "tear" or "curl" when fired. On the other hand, as reported by Sweely and Prince,[1] fine grinding develops opacity in white enamels and we usually find that increased gloss results from fine grinding of the frit particles.

Therefore, most enamelers grind their sheet iron ground coat enamels rather coarse, perhaps as coarse as 30-mesh, and usually not finer than 60-mesh. This promotes even draining at the dipping tank, good covering of the edges and sharp corners on the ware, and usually gives the enamel more "firing range" when in the furnace.

Cast iron enamels (wet process) are usually milled somewhat finer than sheet iron ground coats, but coarser than sheet iron cover coat enamels, perhaps through a 60-mesh or even an 80-mesh screen, but 5 to 10% remaining on a 100-mesh.

Sheet iron cover enamels are usually milled to as high a degree of particle fineness as may be possible without getting into dipping difficulties, or drying trouble, in order to develop opacity and gloss.

Colored enamels, that is, blues, grays, greens, walnuts, mahoganies, etc., are usually milled to small particle size in order to develop uniformity of color, and to eliminate the faint mottled or "grainy" effect caused by grains of uncolored frit showing up in a colored background.

It is not the writer's purpose however, to recommend any certain screen tests which enamel slip should pass before it is used, for this will vary in different shops and with different enamels, but more particularly to call attention to the need for *uniformity* of grinding of any certain enamel in any certain shop if uniform results are expected from the enamel. This applies more particularly to the need for uniform grinding of colored enamels if uniform colors are desired.

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[1] *Loc. cit.*

The Need of Uniform Mill Practice

The writer several years ago was in a large enameling plant when suddenly, literally overnight, the gray enamel in use in the shop began coming "off-color," in fact, it was so much too dark that it would not pass inspection.

The natural inference, of course, was that the mill room man had made an error in weighing either the frit or the coloring oxide, and consequently the next mill was weighed out by the shop superintendent himself, and the mill room man measured out the water. This mill of enamel, however, was also too dark and the mystery was still unsolved.

The writer, when appealed to for help, inquired as to what was the standard milling practice. He was told that the mill formula called for 5 pounds of clay, 2 pounds of tin oxide, and 4 ounces of black oxide, per one hundred pounds of frit. The mill held 800 pounds, so 32 ounces of black oxide, 16 pounds of tin oxide, 40 pounds of clay, 800 frit, and sixteen buckets of water filled to a certain mark were used. This was ground for eight hours, then the mill was opened and two hundred pounds of spray booth scrapings and five buckets full of water were added and it was ground for thirty minutes more.

On the last two mills, instead of adding sixteen buckets full of water, only fourteen buckets were added and the enamel was done in six hours. Then when the spray booth scrapings were added, seven buckets full of water were put in instead of five as usual.

There was the answer to the mystery. Another mill was started and run according the original practice, with the result of a perfect color match. This plant later was able to adopt the mill practice that the mill room man had disastrously tried out, by reducing the black oxide content of the batch from four ounces per hundred pounds of frit to two and seven-eighths ounces.

The Effect of Too Small a Mill Charge

The writer was also called into consultation several years ago at a plant which was finding hard rough particles in the surface of the fired ground coat enamel. These particles were so small that they passed through the 40-mesh screen along with the milled enamel, but on close examination they could be seen in the dipped ware, and being non-fusible at the enamel firing temperature, they refused to flow, but stood out in the surface like boulders on a rocky hillside. Every piece of fired ware had to be closely inspected and "stoned down" before the white cover coat could be applied.

A few of these particles were removed from the unfired ground coat with a pair of sharp tweezers and were examined with a small magnifying glass. There seemed to be about an equal division of white porcelain-like particles and brown sandlike particles.

The lining of the pebble mill was examined for breaks or worn spots, but was found to be in good condition, as it had been relined about two months previously.

The mill, however, which was four and one-half feet long and four and one-half feet in diameter (inside measurements), was only about one-quarter full of pebbles, whereas we find that the majority of ball mill manufacturers recommend such a weight of pebbles that the mill is about half filled with grinding media. It seemed quite probable under these circumstances that the hard particles in the enamel were nothing more or less than abraded porcelain lining and crushed flint pebbles, particularly since it had been noticed earlier in the day that the mill did not seem to grind with a steady "rumble," but rather that the pebbles were pounding in intermittent surges.

There were no more pebbles available, with which to load the mill up to specifications, so we tried the next best method of increasing the mill load. The mill had previously been loaded with 750 pounds of enamel frit, and the necessary clay, water, etc., which only half filled it. We increased the charge to 1500 pounds of frit, which necessitated a lengthening of the grinding time from seven to eleven hours, and were quite pleased to note that the mill then revolved with a steady grinding rumble and to learn the next day that our new milling of ground coat was free from the contamination which had been causing trouble.

Effect of Too Small a Charge of Frit on Color and Gloss of the Enamel

The writer recently tried an experiment with a sheet iron cover enamel which had the necessary oxide additions to make a light-tan colored enamel. The mill used had a porcelain block lining and measured thirteen and one-half inches long and twenty-six inches in diameter (inside dimensions). It was one-half filled with flint pebbles averaging about one and one-quarter inches in diameter.

The mill was first charged with fifty pounds of frit, and the necessary clay, oxide, water, etc. The contents were milled to pass 100-mesh, with only a small residue of coarse glass from around the mill head and what seemingly was a small amount of crushed pebbles remaining on the screen. This enamel, when fired, was quite lacking in gloss and was very badly off-color.

The mill charge was increased to seventy-five pounds of frit with proportionate amounts of the necessary clay, oxide, water, etc., and again the contents were milled to pass 100-mesh. This batch of enamel fired to a high gloss, and the clear sharp color of the correct shade.

This is simply another example of how undercharging the mill led to so much contamination of the enamel with particles of porcelain and particles of silica pebbles, that the enamel had but little gloss and was altered in color.

With white enamels, ground in porcelain lined mills with porcelain grinding pebbles, one would of course notice no serious change in color but the writer knows of two cases where undercharging of the mill led to lack of gloss in the finish enamel.

"Breaking-in" New Mills

It is undoubtedly a regular procedure in every enameling plant to clean and scour a new mill carefully, or a mill which has just been relined, before it is used.

This cleaning usually consists in loading the mill with sharp sand and water, and running it for a day or two. The addition of 2 or 3% of clay to the above cleaning mixture can be recommended to keep the sand in suspension and to keep it from caking in the bottom of the mill before it is drained off. Oftentimes scrap enamel is also used for scouring or cleaning out a mill.

Occasionally, even if a mill has been so thoroughly cleaned that seemingly there is no contamination, it will happen that the first few millings of enamel are "too short" or have too much "set up," particularly if the enamel is applied by dipping and the regular amount of setting up agent has been added as part of the mill charge.

This is seemingly caused by a small amount of the cement in the mill lining being ground off into the enamel, which is in turn "set up" by this addition.

It is a known fact that Portland cement will "set up" an enamel suspension, and the writer knows of several cases where ground coat enamel milled in a newly relined mill was entirely too "short," while the same mixture prepared in an old mill had the proper dipping properties.

The obvious remedy for this difficulty, if it occurs after a thorough cleaning, is to prepare the next mill of enamel without any settingup agent whatever or with a smaller amount than usual, and to then use whatever additional amount of settingup agent at the dipping tank that may be necessary to obtain the usual working properties.

Fineness of the Enamel

Control of grinding by merely running a ball mill a certain number of hours, or even by using a revolution counter does not insure that the enamel will always be milled to the same degree of fineness unless other conditions are constant.

Uniform grinding requires: (1) constant amount of pebbles, (2) constant weight of mill charge of enamel, etc., (3) constant amount of water, and (4) constant number of revolutions of the mill. This does not take into consideration the faster grinding due to the wearing away

of the lining of the mill, so every few months perhaps the grinding can be decreased a few hundred revolutions.

Perhaps the best check on the uniformity of grinding and on particle fineness of the enamel is a screen analysis. For an intelligent screen analysis, at least two screens or sieves should be used. These should be of such mesh that the enamel slip will pass the first screen, and a small amount (5 to 10%) be retained on the second screen. A weighed or measured amount of the enamel slip to be tested should be poured upon the nested screens and carefully washed through with a gentle stream of water. The residue remaining on each sieve, after thorough washing, should be dried and weighed, or may, after some experience, be "estimated" by eye.

It should be emphasized that the washing of the enamel through the screen with running water is the only proper way to conduct a screen test, for this thoroughly thins the enamel slip, allowing it to flow easily and washes through the sieve all the fine particles, leaving only the coarse particles which form the "residue" on that particular mesh sieve. Many a batch of cover coat enamel which seems to be milled to 80-mesh when passed through such a sieve as it comes from the mill will in reality be found to pass a 100-mesh screen or even finer if washed through with running water.

The Cone Screen Test

Another convenient method of determining the particle fineness of the milled enamel with speed and a fair degree of accuracy is that of passing it through a "cone screen" such as is shown in Fig. 1.

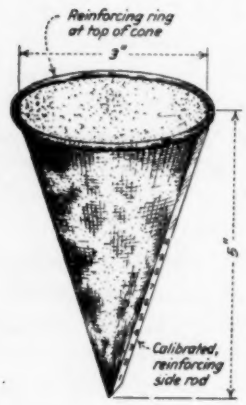

FIG. 1.

The particular cone screen illustrated has a diameter of three inches and a height of five inches. It may be constructed from whatever mesh screen that may be desired, but this mesh should be such that a small residue will be left in the "apex" of the inverted cone. This residue, instead of being weighed, is calculated from the calibrated scale attached to the side of the cone.

To give a specific example of its use, a plant enameling refrigerator linings, etc., uses a cone screen constructed from 80-mesh screen. A standard quantity of enamel from the mill to be tested (a pint or a half-pint), is poured slowly into the cone which is held under a stream of water running gently from a watertap. All the enamel is transferred to the cone by rinsing out the measure and is washed through the screen. The residue is washed

down into the point of the cone, the amount being determined by reading its height on the calibrated scale on the side of the cone. Using a half-pint sample of enamel, a residue of about one-half inch to five-eighths of an inch in the bottom of the cone indicates what this company considers proper particle fineness for its particular class of work. More residue than this indicates that longer milling is necessary, less residue that the enamel is already too fine.

For flatware and cooking utensil cover coat enamels it would perhaps be advisable to use a cone constructed from 100-mesh or 120-mesh screen, while for sheet iron ground coat enamels, coarser mesh screen such as 50-mesh or 60-mesh would be desirable.

Conclusions

To sum up, the following practice assists in producing uniformly milled enamels:

(1) Keep the mill at least one-half full of pebbles.

(2) Load the mill with enough enamel frit, clay, oxide, water, etc., that the charge, when milled, will *cover* the pebbles in the mill. Then when the mill revolves, each pebble will fall on material to be ground. This decreases the amount of pebble and lining contamination in the enamel, as the pebbles do not grind themselves to pieces, and at the same time it contributes toward grinding efficiency, for then each pebble is at work in smashing or rubbing down the enamel particles surrounding it.

(3) For a given enamel, always add the same amount of water, either by measuring or weighing. Do not guess at it.

(4) Grind the enamel to the same degree of particle fineness from day to day, by careful control of the number of mill revolutions per milling, and check this from time to time with a screen analysis.

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III. PROGRESS REPORT ON INVESTIGATION OF SAGGER CLAYS: THEIR ELASTICITY AND TRANSVERSE STRENGTH AT SEVERAL TEMPERATURES[1]

By R. A. Heindl and W. L. Pendergast

ABSTRACT

This is a third Progress Report, based on data obtained in an extensive investigation of sagger clays for the purpose of determining the properties characterizing clays best suited to this type of service. The Report contains a brief description of the apparatus used in the determination of elasticity and transverse breaking strength at three temperatures, ranging up to 925°C. These data are correlated with thermal expansions of clays, as given in the second Progress Report, resulting in the formation of an empirical formula which indicates the relative resistance of saggers to failure due to thermal shock. The majority of clays show an increased rigidity or elasticity at the higher temperatures, but only those clays which are weak at room temperature indicate a marked increase in transverse strength.

Introduction

In the first Progress Report of this investigation[2] data were given which served as a basis for the grouping or classifying of fifty-one sagger clays according to their firing characteristics. As stated in the Report, it was proposed to continue the work by a more fundamental study. Accordingly, the thermal expansion of the clays has been studied and the results of the observations published in the second Progress Report of this investigation.[3] In continuation of the proposed fundamental study, the transverse strength, and deformation due to increasing increments of load, were observed on seventeen clays at (*a*) room temperature, (*b*) the temperatures at which saggers made from these clays failed in an air-quenching test described in the first report (ranging from 350 to 925°C), and (*c*) at 750°C.

This paper reports the results of the determinations together with some observations of the elastic characteristics of the various clays and of the apparent relation of the modulus of elasticity to porosity, and transverse strength. An empirical formula has been derived, combining the properties of modulus of elasticity, transverse strength, and the coefficient of linear thermal expansion, which appears to give a factor indicating relative resistance of saggers to thermal shock.

Description of Specimens

Specimen bars made of 50% clay[4] and 50% grog were prepared and fired at 1230°C in a manner similar to that described in the first Report.[5]

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[1] Published by permission of the Director, U. S. Bureau of Standards, Department of Commerce. Received March 28, 1927.

[2] *Jour. Amer. Ceram. Soc.*, 9 [3], 131–43 (1926).

[3] *Ibid.*, 9 [9], 554–74 (1926).

[4] Laboratory numbers of clays correspond to those used in first and second Progress Reports and may be so identified.

[5] *Loc. cit.*

The specimens were about one inch square in cross-section and eleven inches long. A span of ten inches was used in the tests and the cross-section dimensions, taken at the point of rupture, were measured to one-thousandth of an inch. Several factors were given consideration when deciding on the size and form of test specimens. The thickness of the specimen conforms with that of the walls of the test saggers. They were made square in cross-section for convenience in molding. In fixing the length of the specimen bars, consideration was given to the effect of the length of span upon magnitude and ease of measuring the deflections, but the choice of the length was governed primarily by the desire to reduce to a practical minimum the effect of shearing deformations on the deflections. With a bar 0.9 inch in depth (average depth of fired specimens) and with a 10-inch span, it appears safe to assume that the entire deflection under a centrally applied load is due to bending. Without a knowledge of the value of either the modulus of elasticity in shear or the value of the modulus of elasticity in bending[1] it is impossible to calculate what proportions of the total deflection are due to shear or to bending, but if it is assumed, for estimating this proportion, that the modulus of elasticity in shear is 40% of the modulus of elasticity in bending, it is found that (for a bar having a ten-inch span and 0.9 inch in depth) the deflection due to shear is approximately 2.4% of the total deflection. As a comparison, a bar of the same depth but a span of four inches would have a deflection due to shear of approximately 13.2%. These values are obtained as follows:

$$\frac{S}{\Delta} = \frac{3d^2}{3d^2 + l^2}$$

where:

S = deflection due to shear
Δ = total deflection
d = depth
l = span

While the relation

$$\frac{G}{E} = 0.40$$

(where G is the modulus of elasticity in shear and E is the modulus of elasticity in bending) is purely an assumption, any other assumed

[1] The modulus of elasticity (lbs. per sq. in.) is the ratio of the increment of stress (lbs. per sq. in.) to the increment of strain (inches per inch) within the elastic limit, *i.e.*

$$\text{Modulus of Elasticity} = \frac{\text{Stress}}{\text{Strain}}$$

value, within reasonable limits would indicate that, with a span of ten inches, the deflection due to shear would be less than 3% of the total deflection.

Description of Apparatus

The construction of the apparatus used in observing deflections and determining transverse strength is indicated by the sketch in Fig. 1.

The furnace proper is of the horizontal muffle electrically heated type, the heat being generated by two nichrome wire units placed against the side walls of the furnace. A rheostat, connected in parallel with the heating units, provides means for the necessary temperature control.

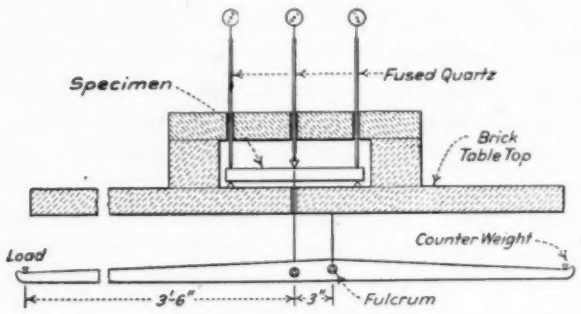

FIG. 1.—Sketch of furnace and apparatus used in the determination of elasticity and transverse breaking strength.

The furnace is built as an integral part of the top of a table as illustrated in Fig. 1. The simple lever arm and fulcrum are fastened to the iron plate which forms the base of the table top, the center line of the lever arm coinciding with the vertical plane passing through the longitudinal center line of the specimen and of the furnace. The fulcrums are spaced to give a fifteen to one ratio at the straining clevis and an extension of the lever arm is used for counterbalancing the lever arm and attachments. Emery fulcrum plates have been used at the fulcrum and the yoke in place of knife edges to insure the constancy of the fifteen to one ratio. The applied load is transmitted to the specimen in the furnace by means of two stirrups and a saddle of heat resistant alloy. Application of the load is obtained by means of No. 12 birdshot flowing at the rate of one ounce each second from a reservoir, attached to the table, to a container hung on the lever arm. The flow of the shot is accurately controlled by means of valves actuated by solenoids. The apparatus is also equipped with an automatic cut-off actuated at the instant the specimen is ruptured.

Loads are applied in either 4- or 8-ounce increments, depending on the relative rigidity of the specimen, and the bending at the center is observed for each 60 or 120 ounces of direct load. Each increment

of load is poured into the reservoir before gage deflection readings for the preceding increment of load are recorded and an interval of approximately five seconds elapses from the time the load is applied until deflections are recorded. Check determinations are made of the first increment of load.

Fused quartz rods, one end of each of which is tapered to a point, are placed at the proper positions on the specimen and any deformation is transmitted to the gages (Fig. 1).[1] One rod is placed at either end over the knife edge and the third is placed in line with the central knife edge through a small hole drilled through the saddle.

The set-up of the apparatus and specimen is accomplished by placing the test specimen on two knife edges of the rocker type, which provide a uniform bearing. The third knife edge, which is the saddle of the straining clevis, is placed on top of the specimen (Fig. 1) midway between the knife edges and the upper end of the stirrups slipped on to the saddle.[2] The cover of the furnace is placed in position and the three fused quartz rods are inserted through the cover. The gages are then placed in position and adjusted. The two base metal thermocouples necessary to control properly the temperature within the furnace are inserted through the top of the furnace. One thermocouple is placed near one end of the specimen and the other is placed at the opposite end.

Calibration

The movements recorded by the micrometer dials due to the application of loads to the test specimen include not only the flexure of the specimen but also any movements occurring in the furnace foundation and specimen supports. The true deflection for each increment of load applied to a specimen is obtained by deducting the movement indicated by the center gage from the average movement indicated by the two end gages.

The accuracy of the apparatus was determined by using a specimen of cold rolled steel measuring 10 by 1 by $\frac{3}{8}$ inches. A load-deflection diagram was plotted for steel using a value of 29,500,000 lbs./sq. in.[3] and the values obtained with this apparatus were compared with the curve. The maximum variation between the two curves was less than

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[1] A description of the adjustable gage mounting is given in the second Progress Report, *loc. cit.*

[2] Thin metallic plates $\frac{1}{2}$ inch wide are placed between the knife edges and the specimen to prevent cutting of the clay against the knife edges. Tests indicated that the use of these plates did not affect the accuracy of the determinations.

[3] Modulus of elasticity of steel ranges from 28,000,000 to 31,000,000 lbs./sq. in., Marks, Mechan. Eng. Handbook.

5%. The accuracy of the lever ratio was determined by placing a counter scale directly above the straining clevis and connecting them so that the application of a load at the end of the lever arm was indicated by the scale.

Precision

The counter scale used for weighing shot is graduated to $\frac{1}{16}$ of an ounce and is sensitive to approximately one-third of that weight. Automatic cut-off of the flow of shot occurs at almost the instant the specimen is ruptured. Readings of deflections indicated by the micrometer dials were estimated to one-fifth of a division or 1/50,000 of an inch.[1] The difference in temperature between the two ends of the specimen did not exceed 10°C.

In calculating the modulus of elasticity the deformation due to shear was neglected. As previously shown, this procedure appears to be justified by the method of testing described.

Results

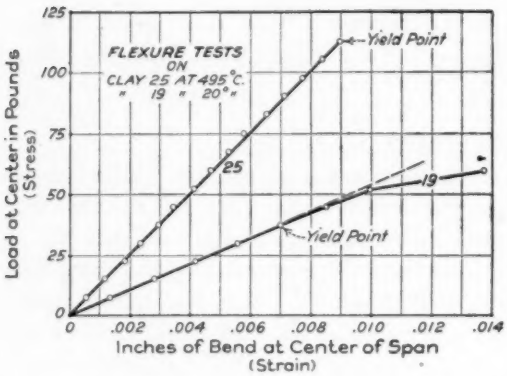

FIG. 2.—Curves showing the typical stress (load) strain (deformation) relationship of two representative sagger clays.

A. Modulus of Elasticity

The data obtained with individual clays previously fired at 1230°C are given in Table I and the deflections of two typical clays corresponding to various loads and plotted to a convenient scale (load-deflection curve) are shown in Fig. 2. In some tests it was found that a few points were not in a straight line (curve 19, Fig. 2), but in the majority of tests all points fell in a straight line up to the point of rupture (curve No. 25, Fig. 2). The curves plotted using values obtained with this instrument indicate that Hooke's law[2] holds true and also that the yield point and point of rupture of clays of the type of No. 25 are reached simultaneously. In the case of clay

[1] Gages are accurate to approximately 1/20,000 inch.

[2] Hooke's law states that within the elastic limit, the deformation produced is proportional to the stress.

TABLE I

PROPERTIES OF SAGGER CLAYS FIRED AT 1230°C AND TESTED AT

		20°C			Temperature at Which Sagger Failed in Quenching Test				750°C		
		Modulus of				Modulus of			Modulus of		
Clay No. (*a*)	Softening point (in cones)	Elasticity (*b*) lbs./in.²	Rupture lbs./in.²	Porosity (per cent)	°C	Elasticity (*b*) lbs./in.²	Rupture lbs./in.²	Coeff. of linear (*c*) thermal expansion	Elasticity (*b*) lbs./in.²	Rupture lbs./in.²	Group (*d*)
6	M*	889	600	32.3	410	1,120	825	9.8	2,600	1,400	
16	M*	934	635	42.5	925	1,130	960	6.9	1,690	1,050	*A*
19	30+	1,530	1,380	34.4	800	3,350	1,850	6.4	3,450	1,770	
24	32	2,770	2,180	28.7	570	3,350	2,540	5.6	4,920	2,060	
25	M*	3,570	2,450	33.6	495	4,590	2,330	6.7	5,280	2,425	
41	30+	3,110	2,350	35.8	350	3,280	2,290	9.9	3,780	2,430	*B*
42	30	2,230	1,460	23.6	745	4,510	2,530	5.9	—	—	
49	32	2,370	1,710	36.8	460	3,050	1,940	7.4	3,800	1,930	
5	30	4,910	3,140	22.0	370	6,030	2,965	7.2	6,000	3,150	
32	15+	5,610	2,310	13.3	515	6,850	2,360	4.6	7,100	2,525	*C*
35	20+	6,940	3,360	13.7	575	8,460	3,080	4.7	7,700	2,675	
18	20+	5,950	3,010	16.7	405	6,960	2,835	5.8	7,840	2,960	
36	20+	5,980	2,020	14.1	545	5,850	2,200	5.2	5,750	2,340	*D*
37	14+	9,430	3,920	2.6	480	8,880	3,420	4.3	8,520	3,460	
15	16+	5,210	3,305	15.4	580	5,910	2,890	5.7	7,570	3,070	
38	26	5,080	2,935	18.7	535	5,100	2,680	5.5	7,160	3,430	*E*
39	29	5,090	3,370	18.9	565	6,070	2,980	4.7	6,460	2,425	

* Higher than cone 33.

(*a*) Identification numbers of clays correspond to those used in the first and second Progress Reports published in this investigation.

(*b*) To be multiplied by 10^3

(*c*) Values to be multiplied by 10^{-6}

(*d*) See first Progress Report, *loc. cit.*

No. 19, a clay of high porosity and low strength, a definite yield point[1] is shown with a direct load of 37½ pounds although the specimen is not ruptured until the application of a load of 60 pounds. The slope of the straight portion of the line is used in computing the modulus of elasticity in the usual manner as applied to bars of rectangular cross-section when the load is applied at the center of the beam, by the formula:

$$E = \frac{Pl^3}{4 \times \Delta \times bd^3}$$

where:

E = modulus of elasticity
P = load at any convenient deflection
Δ = deflection at selected load
b = breadth
d = depth
l = span

The modulus of elasticity of seventeen clays was determined from observations at room temperature, at the temperature of failure of saggers[2] in the air-quenching test, and at 750°C. The data are given in Fig. 3. The clays have been divided into three groups according to their elastic properties at elevated temperatures. The group in the center section (Fig. 3) showed a decrease in modulus of elasticity at the highest temperature; the group in the section to the left showed a greatly increased modulus of elasticity at the highest temperature and, the group to the right includes clays which showed an increase in modulus of elasticity approximately proportional to temperature increase. The data indicate that, for 15 of the 17 clays tested, there is a marked increase in modulus of elasticity at 750°C as compared with that obtained at room temperature. The clays in groups (*A*) and (*B*),[2] although having the lowest initial modulus of elasticity, indicate the greatest increase with increase in temperature. Since modulus of elasticity equals stress/strain (or,

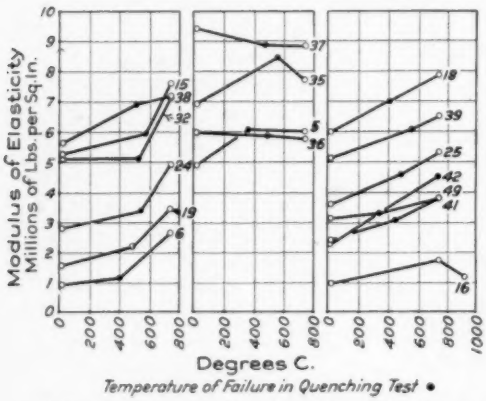

FIG. 3.—Curves showing the variation in modulus of elasticity of seventeen representative sagger clays.

[1] The yield point is indicated when a definite trend of the points is below the straight line continued and indicates that the rate of bending of the specimen is no longer proportional to the applied load.

[2] *Loc. cit.*

strain times modulus of elasticity equals stress) any increase in modulus of elasticity without a proportional increase in the transverse strength is detrimental to the life of the sagger.

B. Porosity The porosity was determined on two-inch pieces cut from the bars used in the elasticity determinations. Determinations were made according to the standard AMERICAN CERAMIC SOCIETY method[1] except that the specimens were boiled in water for four hours and were permitted to remain in the water over night before weighing. The porosities are given in Table I and averaged for the groups in Table II.

TABLE II

Group	Average modulus of elasticity lbs./sq. in. (room temperature)	Average porosity of specimens (per cent)
A	1,120,000	36.4
B	2,810,000	31.7
C	5,820,000	16.3
D	7,120,000	11.1
E	5,120,000	17.7

Table II, and the plotted values in Fig. 4, indicate that a general relation exists between modulus of elasticity and porosity; *i.e.*, an increase in modulus of elasticity is accompanied by a decrease in porosity. Bleininger[2] found this relation to be true for a number of clays used in paving and fire brick. It is realized that this relation is indicated in an approximate way only; an explanation of the variations as found would probably require statistical data and these are not now available.

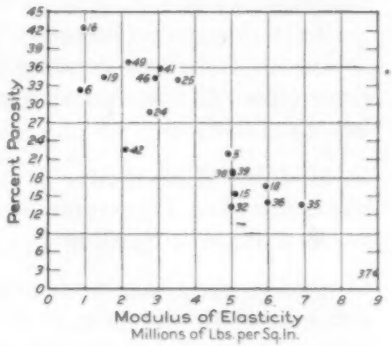

FIG. 4.—Showing the relation between modulus of elasticity and porosity determined at room temperature.

C. Fired Strength (Modulus of Rupture) The load used in the modulus of rupture computations was obtained from the flexure tests, the load having been increased until rupture of the 10-inch specimen occurred. Values determined at room temperature and plotted as in Fig. 5 indicate that a relation exists between transverse strength and modulus of elasticity, *i.e.*, that the modulus of elasticity increases with increased transverse strength. This relationship is also only

[1] Report of Committee on Standards, *Year Book American Ceramic Society*, 1921–22.

[2] A. V. Bleininger and G. H. Brown, *Trans. Amer. Ceram. Soc.*, **17**, 464 (1915).

approximate and the explanation for the variations is not evident from the data at hand.

The clays in group A and clay No. 42 in group B show a pronounced increase in strength (modulus of rupture) at 750°C as against values obtained at room temperature, only two clays (Nos. 35 and 39) show a rather sharp decrease, and the remainder of the clays do not show either a pronounced increase or decrease in strength at 750°C as compared with that obtained when tested at room temperature. Observations made on two specimens of clays (including one of the most refractory in the group) indicated that plastic deformation took place at 950°C with a load as low as 60 lbs./sq. in.[1] No indication of plastic deformation was noted in any of the clay specimens at the lower temperatures irrespective of the applied load.

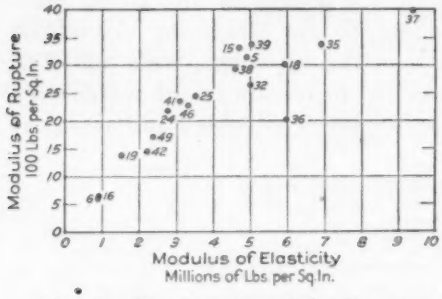

FIG. 5.—Showing the relation between modulus of elasticity and transverse strength (modulus of rupture) determined at room temperature.

Check determinations were made at room temperature on all clay specimens and check determinations were made on specimens of three clays (Nos. 32, 36, 38) at higher temperatures. The results varied less than 10%.

D. Modulus of Elasticity, Expansion, and Transverse Strength vs. Resistance to Spalling

Some data have been presented by Norton[2] and Booze[3] indicating a possible relation between resistance of fire brick to spalling and the three factors (1) modulus of elasticity, (2) thermal expansion, and (3) rate of temperature change or diffusivity. The diffusivity has been disregarded in this work. Norton[4] states that diffusivity is not usually an important factor in the tendency of refractory materials to spall and gives a series of values for diffusivity of

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[1] S. C. Linbarger and C. F. Geiger, (*Jour. Amer. Ceram. Soc.*, **3** [7], 543 (1920)) obtained some data on the breaking strength of pieces of saggers, R. F. Geller (*Jour. Amer. Ceram. Soc.*, **4** [7] 608 (1921)) on fireclay tile, and M. L. Hartmann and W. A. Koehler (*Trans. Amer. Electrochem. Soc.*, **39**, 129 (1921)) on fireclay brick at temperatures over 1200°C and found the transverse strength to be greatly decreased at these high temperatures.

[2] F. H. Norton, *Jour. Amer. Ceram. Soc.*, **8** [1], 29 (1925).

[3] M. C. Booze and S. M. Phelps, *Jour. Amer. Ceram. Soc.*, **8** [6], 361 (1925).

[4] F. H. Norton, *Jour. Amer. Ceram. Soc.*, **10** [1], 30 (1927).

a number of fireclay bricks which indicate a relatively small variation in this property under like conditions of heating.

Although a failure in a sagger due to rapid temperature changes may not be strictly comparable to a spall in a fire brick, it is believed that the modulus of elasticity, thermal expansion, and transverse strength are the most important factors in determining the resistance of a sagger to thermal shock.

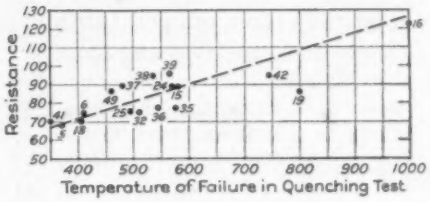

FIG. 6.—Showing resistance (R) of saggers to spalling. Data used in computing the resistance factor were determined at temperatures at which saggers failed in the air-quenching test and the factors so obtained are plotted against the temperatures at which the saggers spalled.

Table I indicates that the majority of clays increase in modulus of elasticity, or in other words are less easily deformed elastically, when the temperature is increased, within the range of temperatures used in this investigation. The transverse strength (modulus of rupture) increases somewhat, but not uniformly, with temperature, while the modulus of elasticity increases more rapidly, which, as previously pointed out, is detrimental to the life of the sagger. The three factors, (1) modulus of elasticity, (2) expansion (the properties which tend to cause failure in the sagger) and, (3) transverse strength (the property tending to increase the life of the sagger) may be combined in an empirical relation such as:

$$R = \frac{M}{E \cdot e}$$

where:

R = factor indicating relative resistance of a sagger to failure
M = modulus of rupture
E = modulus of elasticity
e = coefficient of linear thermal expansion

Table III gives a series of values representing the calculated resistance factors (R) of 17 sagger clays at room temperature, at the temperature at which saggers failed in the air-quenching tests, and at 750°C. In Fig. 6 the computed resistance factors obtained with data determined at the temperature at which saggers failed in the air-quenching test, are plotted against this temperature. The relation between the calculated resistance (R) and the life of the sagger as indicated by the quenching test is clearly indicated by the trend of the points. A similar relation is shown when plotting the values in Table III as determined at 750°C, but when plotting the values obtained at room

temperature (Table III) against the temperature of failure of the saggers no such relation is indicated. It may, therefore, be concluded from these data that, in order to obtain some factor which will indicate the relative resistance of a sagger to failure due to thermal shock, it is essential that the properties be determined at some temperature other than room temperature and preferably between 500°C and 750°C.

TABLE III

Clay No.	Saggers failed in-quenching test at °C (1)	Resistance Factor (R) Using Properties Obtained at Room temperature (20°C) (2)	Temperature of failure (b) °C (3)	750°C (4)
41	350	72.2	70.4	56.8
5	370	81.0	68.3	84.0
18	405	85.3	70.3	66.1
6	410	58.5	75.0	62.6
49	460	90.5	86.6	71.8
37	480	72.2	89.6	66.9
25	495	85.6	75.8	77.0
32	515	157.6	89.5	72.1
38	535	109.2	95.0	84.5
36	545	72.7	77.6	74.2
39	565	139.0	95.8	80.7
24	570	146.0	89.4	76.2
35	575	121.0	77.4	73.1
15	580	137.0	89.0	76.0
42	745	130.5	95.2	95.2
19	800	93.7	86.2	77.3
16	1000(a)	62.6	122.8(a)	82.0

(a) Sagger had not failed at 1000°C. Properties determined at 925°C.
(b) For values see column (1).

Summary

The majority of clays was found to increase in modulus of elasticity when tested at 750°C as against values obtained at room temperature. Only those clays which were comparatively weak at the lower temperatures increase greatly in strength at 750°C, the majority of clays showing little variation from the cold strength tests. Only two clays show a marked decrease in strength at 750°C.

The data indicate that an approximate direct relation exists between transverse strength and elasticity and an inverse relation between porosity and elasticity.

An empirical formula was developed, using data obtained at elevated temperatures, which give an indication of the relative resistance of saggers to failures due to thermal shock.

A few tests made on one of the most refractory clays used in the investigation showed that plastic deformation began at temperatures as low as 950°C with a load of approximately 60 lbs./sq. in. It is contemplated to determine the load required to cause plastic deformation at about 1000°C on each of the 17 clays used in this phase of the work.

NOTE ON THE SOLUBILITY OF FIRED BODIES IN HOT SULPHURIC ACID[1]

By A. V. Bleininger

ABSTRACT

This work is an application of the so-called mineral analysis to bodies fired to a maximum temperature corresponding to cone 9, for the purpose of establishing a measure of the progressive vitrification. It is based on the assumption that the solubility of an earthenware body in hot sulphuric acid decreases with the temperature of firing, as the porosity decreases. In general, this was found to be true but in order to obtain consistent results it is necessary to maintain standardized conditions of procedure especially in the grinding of the sample and in the treatment with fuming acid. The procedure has shown solution of as much as 66% of the anhydrous clay substance with a porosity of 17.9%.

Introduction

It is a well-known fact that the solubility of clay substance in fuming sulphuric acid has been made the basis of the so-called mineral analysis. This analytical method has been applied both to hydrous and to anhydrous clay, the latter being obtained by heating to 600°C. In the present work which deals with an earthenware body it was desired to trace the connection between the degree of partial vitrification as indicated by the absorption or porosity, and the real internal changes which take place. It is well known that a body which has been fired under two sets of conditions but shows identical porosities may differ decidedly in physical characteristics. In other words, the absorption, *per se*, fails to point out the degree of sintering or vitrifying action attained, except in a crude way. We should like to know how the feldspar and the vitrifying ball clays affect the real structure of the body. Since vitrified bodies are but slightly soluble in fuming sulphuric acid it was thought that the tracing of the decreasing solubility between the high and the lower porosities might afford a criterion of the real condensing phenomena. We should expect that the bodies would be the more soluble the less heat treatment they have received. In proportion as the various fluxes become effective and complete vitrification is approached the solubility should diminish and finally become nil. It is evident that the attack of the fuming acid centers upon the clay matter of the anhydrous body. All of the clay substance should be dissolved when just dehydrated and the solubility should diminish according to the heat treatment which the body has received.

Procedure

The determination of the solubility was made according to the method of the so-called mineral analysis. But in dealing with fired material it is evident that the fineness of grinding is a factor of con-

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (White Wares Division) Received May 4, 1927.

siderable importance. The finer the sample is ground the greater must be the solubility, other conditions remaining the same. The amount of dissolved matter should vary according to the relation:

$$d = kps$$

where d is the amount of dissolved matter, k is a constant depending upon the heat treatment, p is the porosity of the body, and s is the surface factor of the powdered sample.

It is hence necessary to maintain the fineness of the sample as constant as possible. In this work the material was ground in a porcelain mortar and that portion used which passed the 120- but not the 200-Tyler sieve. The dust passing the latter was rejected. It is possible that some other sizing might yield more satisfactory results. In dealing with porcelains finer powders probably would be better.

The analytical procedure was carried out as follows: One gram of the powder is weighed and transferred to a casserole. To this 50 cc of a 1:1 sulphuric acid solution is added. The casserole is then heated until the acid fumes strongly, a condition which must be maintained for five hours. Unless the fuming is vigorous no concordant results will be obtained. The casserole is allowed to cool and the acid largely diluted with water. While still hot from the heat of dilution the solution is filtered and washed with hot water. The residue transferred to the filter is washed back into the casserole and 25 cc of Lunge solution, (100 grams Na_2CO_3 and 10 grams NaOH per liter) is added. This is boiled for five minutes and filtered while hot. The residue is washed back into the casserole and the treatment repeated twice more. The residue is finally completely transferred to the filter, washed with hot water and hot dilute HCl solution. The precipitate is then ignited and weighed.

Owing to the absence of test kiln facilities the samples were obtained both from periodic and tunnel kilns. The specimens of ware selected were tested for absorption and prepared for analysis. With the same sample and exactly identical procedure the results could be checked within 1%. But specimens of the same absorption often varied widely in regard to solubility in sulphuric acid. Some of the results obtained follow:

Absorption (per cent)	Dissolved matter in terms of body (per cent)	Dissolved in terms of anhydrous clay content (per cent)
2.49	13.11	27.9
4.34	11.56	24.5
7.58	15.22	32.3
8.00	26.02	55.3
9.32	17.09	36.3
10.00	13.50	28.7
11.55	14.87	31.6
10.98	14.84	31.5
11.37	18.34	39.0
10.83	22.90	48.7
17.91	31.14	66.2

In the third column the amounts of dissolved material are expressed in terms of the anhydrous clay matter in the body which amounts to 47%. The results obtained do not show a satisfactory correlation between the absorption and the per cent of dissolved matter, except in a very rough way. The discrepancy may be due either to a failure of the method itself in some part of the procedure, or to the failure of the solubility of the clay matter to have any connection with the body structure. The writer is inclined to believe that the former is the case rather than the latter condition. It is difficult in commercial laboratories to maintain strictly uniform conditions especially in regard to the time element.

Four clays, (1) an English china clay No. 22, (2) a North Carolina kaolin, (3) Kentucky ball clay No. 4, and (4) Kentucky ball clay No. 12 were fired to cone 9 in the bisque kiln and subjected to the same treatment. The percentages of dissolved material were: china clay, 41.15; North Carolina kaolin, 42.44; Kentucky No. 4, 32.59, and Kentucky No. 12, 52.02. It is rather surprising that these clays should show such a decided solubility considering the firing temperature, especially in the case of the ball clays. The latter type of clay has been considered to be rather impervious to acid attack.

The action of hot sulphuric acid on clay just being dehydrated during the early stages of firing is probably very severe and is apt to result not merely in the formation of sulphates of the alkaline earths but in the decomposition of the clay substance and in the formation of aluminum sulphate, as far as the hot acid can penetrate. The quantitative extent of this reaction obviously depends upon the amount and concentration of the available acid.

A method of mineral analysis should be found which would assist us in tracing the progress of the vitrifying processes and differentiating between the possible molecular changes. If the treatment with hot sulphuric acid offers such a procedure it must be standardized with considerable care.

The solubility of earthenware bodies fired up to cone 9 was found to be greater than was expected. In general, it increased with the porosity of the body but no satisfactory relation could be established. This may be due to failure of the method as to procedure or principle, or to failure of the porosity to express the inner structural status of the clay or body. The porosity may be only a rough criterion of the physical state of the clay materials.

It would be desirable if such methods could be tested out, or a search made for more suitable ones, which would help in tracing the fate of the clay substance during the firing process.

HOMER LAUGHLIN CHINA COMPANY
NEWELL, W. VA.

A STUDY OF COLOR AND ITS APPLICATION TO CERAMIC ART[1]

By Theodore Lenchner

ABSTRACT

Color is recognized as having three dimensions, (1) warmth or coolness, known as *hue*, (2) lightness or darkness, known as *value*, and (3) brightness or dullness, or strength or weakness, known as *intensity* and *chroma*. Two existing color theories, the Prang and Munsell systems, are outlined. The proper application of colors is discussed.

Someone has said that color is the magic gift of nature which transforms a dull drab world into a gay and joyous one. And it is so in the field of ceramics where color is destined to play a most important rôle as a part of decorative design. At the present time the appeal of color is most pronounced, and if color is to produce a feeling of satisfaction and desire to possess, the subject of colors and how to use them must be given some thought and study.

This paper will present the barest outline of two existing color theories which appear to be most in use, the Prang[2] and Munsell Systems.[3]

Color is recognized as having three dimensions, each of which is distinct from each other as length, breadth, and thickness. These are as follows:

1. The warmth or coolness of a color: in both systems designated as *hue*.

2. The lightness or darkness of a color: in both systems designated as *value*.

3. The brightness or dullness, or perhaps the strength or weakness of a color, might be a better term: (in the Prang system known as *intensity*, and in the Munsell system known as *chroma*.) In explanation of these dimensions we shall not deal with the source of color as expressed in wave lengths acting upon the retina of the eye, but merely color as ordinarily used. To simplify the study we shall represent the dimension known as *hue* by a circle. The three fundamental colors we shall place equidistant apart on this circle. These colors are red, yellow, blue. These are called *primary* colors because they cannot be obtained by mixing with any other colors or hues. Now by mixing equal parts of two primary colors we obtain what may be called the secondary colors. There are three of these according to Prang, purple

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[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (Art Division.)

[2] Louis Prang, The Prang Standard of Color, published by Louis Prang, 1898.

[3] For the Munsell system see, A. E. O. Munsell, "A Simple Method of Measuring Color," *Jour. Amer. Ceram. Soc.*, **6** [7], 777 (1923); A. H. Munsell, Color Notation and Atlas, published by Ellis and Wadsworth, 1913; T. M. Cleland, A Grammar of Color, with Practical Description of Munsell Color System, published by Strathmore Paper Company, 1921.

or violet made by mixing equal parts of red and blue; green by mixing equal parts of yellow and blue; orange by mixing equal parts of red and yellow. These six colors according to Prang are the standard or spectral colors. If primary and secondary colors are mixed in equal amounts, we obtain what may be known as intermediate colors. There are six of these, red-violet, blue-violet, blue-green, yellow-green, yellow-orange, and red-orange. These twelve colors may be mixed with their adjacent colors in equal amounts to produce still more colors as for instance by mixing blue and blue-green we obtain blue blue-green, and so on. These twenty-four colors which we now have, head a monochromatic scale in the Prang system which scale will be touched upon later.

In the Munsell system each hue or spectral color is divided into decimals of ten. However, this system eliminates the orange, and the spectral colors contain but five hues. This dimension of color is given a notation according to its place in the decimal system, thus red-violet would be the first decimal, red would be the fifth, and red-orange the tenth.

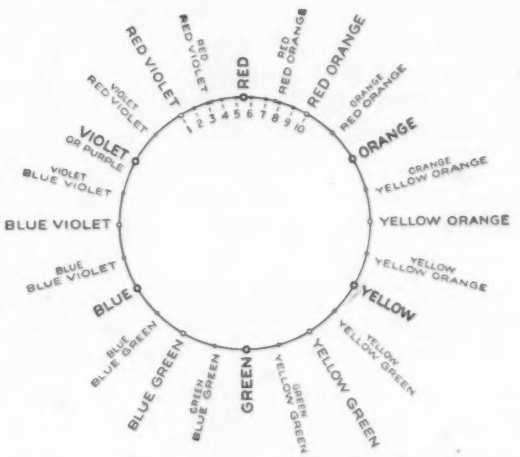

FIG. 1.—Scale of colors: *hue*.

In order to explain the second dimension satisfactorily (lightness and darkness), we shall combine some of the features of the Prang system with that of the Munsell, *i.e.*, a line or pole drawn through the center of the circle and divided into ten steps with black at the bottom and white at the top. Since there are degrees of lightness and darkness, we shall call white the highest value and black the lowest value. Halfway between the white and black comes the middle value. The value of any hue is given a notation by Munsell according to its place in the decimal system from 1 to 9. The values from 1 to 4 which differ in that more color or black is added to darken are called shades of color. The values above five which are changed by adding white or water to lighten are called tints of colors.

The third dimension known as intensity by Prang and chroma by Munsell, we shall indicate by a path drawn at right angles to the pole. This path indicates the strength or weakness of a color. This may be explained by the fact that all colors do not have the same intensity. By physical measurements we know that the strongest red pigment is twice as strong as the strongest blue pigment. Therefore a color at its maximum brightness or intensity would be placed at the extreme end of the path and by a decimal system adopted by Munsell the decrease in intensity is noted. However, it must be noted that all colors do not reach their maximum strength at the same level of value; therefore, the intensity path will touch the pole at different levels. Thus yellow with a chroma value of nine reaches the pole at a light value of eight and would be noted as value 8, chroma 9—yellow 8/9. Blue reaches its greatest intensity at value 4 and would be noted as blue 4/6. A change in the intensity or chroma of a color may be brought about through the mixing with its complement, *i.e.*, any color which lies directly opposite on the chart. As colors become less bright or toward neutral gray or no color they are of low intensity or chroma. To be more specific: if a color at its spectral chroma, *i.e.*, the point at which the path touches the circle, is mixed with an equal amount of its complementary color at its spectral chroma, a gray or neutral color would result. If we mix colors of different chromas to produce a neutral gray a larger amount of the weaker color must be mixed. This is what is known as color balance, according to Munsell.

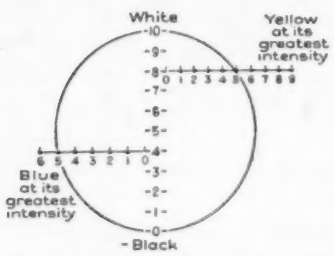

FIG. 2.—Scales representing *value* and *intensity* of colors.

Prang employs a series of color charts or scales. Hue is noted by the name or initials corresponding to the step on which it occurs on the chart. These twenty-four colors head a color series chart, each color of different light value or lightened seven times, *viz.*, Red-Red L_1–Red L_2–Red L_3, etc., totaling 168 colors. Each of these colors in turn appear in another broken series chart where each step represents the addition of complementary color or gray in seven steps, totaling 1,176 colors. Each step is darker than the one preceding and each step is given a numerical value indicating the degree of neutralization; thus Red neutralized $\frac{1}{4}$ would read Red $\frac{1}{4}$ *N*.

Every principle of structural design applies to color also; for instance, balance, proportion, rhythm, emphasis, and unity. Decoration through the use of color that does not enhance or enrich the structural design

is not enduring or beautiful. Therefore, a successful color decoration depends upon the selection of colors and their correct use. To do this successfully the ceramic decorator should know something about color. There are no absolute rules to follow. However, the decorator should be able to picture in his mind every color in its different dimensions. This, of course, requires experience with colors, besides a study of same. The few principles already referred to and which might be termed *essentials of color arrangement* might apply to the use of color on ceramic ware.

The first of these, color balance, we might review again by stating that a color scheme or decoration should be balanced if contrast is desired and a color decoration is balanced when a mixture of all the colors in the proportions in which they are used produce a perfect gray; a color is balanced through the use of its complementary color which lies directly opposite on the chart. For instance, a bright color and a dull color may be balanced if a larger area of the dull color is employed than that of the bright color, *i.e.*, in proportion to their chroma, the values being alike. Another example: a balance of light and dark colors may be produced by using a small quantity of light color or light value to balance a large amount of dark color or dark value. From these facts we may deduce a principle accepted by all colorists, *i.e.*, large areas should contain colors which are dull or quiet, and small areas should contain the bright colors, and the smaller the area the brighter the color should be.

Commenting on the principle of proportion it might be stated that ceramic ware decorated in more than one color would be more interesting if unequal proportions of color were used, however, keeping in mind color balance as outlined above.

Colors are rhythmic when they are so arranged that the eye moves easily from one to another, or they are skilfully repeated.

Emphasis is gained by causing one color to dominate the decoration even though the dominating color is used in its different values and intensities, *i.e.*, one should always be conscious of a main color.

Color harmony or unity may be produced in a scheme or decoration in other ways besides those mentioned under balance. In some cases the presence of a gray or neutral has the effect of harmonizing what would otherwise clash, for instance by placing the color decoration at the center of interest, or using those colors which are well liked in certain localities.

Analogous harmony, or colors closely related, is good but complementary harmony is likely to please for a greater length of time. Some authorities claim that the secret of using colors successfully is by keying or tying them together by adding a color in common to both colors,

for instance a red or yellow with orange, or by using a neutral tone between two colors. These neutral tones may be silver, gold, grey, black, or white.

Colors also have a generally accepted meaning as for instance dark cool colors suggest strength, reserve, depression. Light cool colors suggest freshness; dark warm colors suggest stability, richness, quality. Light warm colors suggest cheer.

Since there seems to be quite an appeal for color at the present moment and since this appeal means more sales through color, we should remember that it is not how many colors or how bizarre the color may be but how colors are used that counts. This applies to ceramic ware of utility as well as for decoration, whether an enameled stove or decorative enamel plaque, whether a terra cotta building or a terra cotta decorative motif, a pottery or glass dinner set or a decorative vase.

Roessler and Hasslacher Chemical Company
New York, N. Y.

FORM AND COLOR IN AMERICAN INDIAN POTTERY NORTH OF MEXICO[1]

By M. R. Harrington

ABSTRACT

Common features in American Indian pottery are the facts that it was strictly hand made without use of any form of the potter's wheel and that it was never really glazed. Due to development of the art in different ways, it is possible to distinguish seven different districts in America. A consideration of the pottery of each district is presented.

It would take a book of no mean proportions to even outline such a subject as "Form and Color in American Indian Pottery" unless we specify, at the very beginning, that by "American Indian" we mean in this case only the tribes living north of the Mexican border; which is, after all, what most people intend when they use the term.

While pottery held an important place in the lives of many of our native American tribes, especially those who practiced agriculture, there were great areas where earthenware in any form was unknown. For instance the Pacific coast was without pottery from central California to Alaska; so was the Rocky Mountain and Plateau country from Utah and Nevada northward, large areas in the Great Plains, and most of northern Canada, except a little fringe along the Arctic coast from Coronation Gulf west to Alaska, where the Eskimo had pottery of a sort. This is shown by the map (Fig. 1), in which the dotted areas indicate the regions where pottery was used, and the blank ones where it was absent.

Fig. 1.—Map showing distribution of aboriginal American pottery north of Mexico.

Even where pottery was used it was by no means uniform; certain groups of tribes had developed the art much more than had others, and

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (Art Division.)

it had been developed in different ways in different districts. We can distinguish roughly seven such districts, the situations of which are also indicated on the map.

But in spite of these differences there are certain features common to American Indian pottery as a whole, the most important being that all of it was made strictly by hand without the use of the potter's wheel in any form. Also, it was never really glazed, although in some parts of the southwestern district lines of glaze were used as decoration.

Perhaps the crudest of all native North American pottery made by tribes still existing, is, or was, found among the Eskimo of Alaska, and at an earlier day along the Arctic coast eastward as far as Coronation Gulf, shown as district No. 1 on our map. Here we have a heavy, coarse ware, taking the form of crude bowls and rough cylindrical jars, without coloring other than the dark browns and blacks produced on the pottery by firing and by use, and without decoration except, in some cases, grooves and ridges impressed in the clay while still soft. There is little or nothing about Eskimo pottery that could be called attractive, or even picturesque. It is seldom, if ever, made today.

FIG. 2.—Crude pot characteristic of the North Atlantic coast, Algonkian Indian origin, incised decoration.

Next in point of crudity is the ware produced by the Algonkian Indians on the North Atlantic seaboard and westward as far as Michigan and Wisconsin, the district marked No. 2 on the map. Here the typical vessel took the form of an egg, (Fig. 2) with the rounded end removed and the pointed end serving as a bottom for the pot, which would not stand alone, but had to be propped with stones, or something of the kind. The color of these vessels was reddish or brownish, usually the natural mottled color of the baked clay; but sometimes a slip seems to have been used to produce a body color different from that of the substance of the pot. There was no attempt to use colors in decoration, but geometric patterns such as chevrons, herring bone designs, or other combinations of straight lines are often seen, drawn into the clay while still soft with a sharp pointed instrument, or impressed with the edge of a shell, or a twig wrapped in native cord; and a body-finish was sometimes produced by patting the vessel while still soft with a wooden paddle carefully wound with cord of this sort. Some of the best incised and impressed geometric patterns made by these people may be seen on their clay pipes. Very rarely a rudely modeled human head or a series of them appears as part of the decoration of a vessel; and even more rare is a

crude line drawing of some living creature, bird or beast or even man, yet such do occur occasionally. This pottery has not been made for generations.

Forming a veritable island in this district No. 2, is the area marked No. 3 on the map, the home of the Iroquois Five Nations and their kinsmen, and here we find a considerable advance and originality in the potter's art, although here also designs in colors were unknown. The typical Iroquois vessel is a graceful thing, (Fig. 3) with a more or less globular body topped by a somewhat constricted neck, which terminates in a neat projecting rim or cornice encircling the vessel, a rim which, in many cases, rises in evenly placed peaks, two or four of them. Upon this rim were incised the designs, almost always combinations of parallel straight lines and dots; while at the peaks may often be seen conventional representations of the human face or figure, usually drawn in while the clay was soft, but sometimes modeled in the round. Such modeling may best be seen in the Iroquois clay pipes, really remarkable for their realistic representation of men and of animals, the forms of which are ingeniously adapted for the use to which they were put, and delineated with a boldness and at the same time a sort of grace which is characteristic. Unfortunately, the potter's art is extinct among the Iroquois.

FIG. 3.—Pottery vessel typical of the Iroquois tribes, incised decoration.

FIG. 4.—Jar showing decoration stamped with carved paddle, South Atlantic district.

The South Atlantic district, No. 4 on the map, was inhabited by a variety of tribes, most of them belonging to what is called the Muskhogean or Creek group, and all of them similar in arts and customs. Their pottery is distinguished by a considerable variety in form, and often a high degree of skill in shaping and finishing. There are many varieties of jars, bowls, and cooking-pots, and some decidedly ornate pipes of clay. A few specimens showing designs in color have been found in this district, and occasional vessels modeled in animal form, but these are all probably intruders from the lower Mississippi district (No. 6) to the west. The use of a paddle for producing a body-finish on the ware, that we have already noticed in district No.1 reached its highest development here; the paddles being carved with intricate designs instead of being simply wrapped in cord. The use

of such a paddle may be seen on the vessel shown in Fig. 4. Incised decoration was also used, but an advance is found here also, for curved patterns, especially the scroll, take the place of those composed entirely of straight lines. Strange to say the potters' art typical of this district survived, with but slight deterioration, among the Cherokee and some of the Creek bands until the first years of the twentieth century, and, for that matter, still exists, in somewhat modified form, but still carried on by ancient methods, among the surviving Catawba Indians in South Carolina.

FIG. 5.—Pottery vase from Lower Mississippi district, showing decoration engraved on ware after firing, and then filled with red paint.

The pottery of the Upper Mississippi region* (District No. 5) offers little of interest to us; there were but few forms, the most typical of which is a globular pot with a slightly raised rim, and simple incised or stamped decoration, mostly in straight lines. It is interesting to note, however, that the most northern tribes of this district that made pottery at all seem to have used a cylindrical form of jar suggesting those of the Alaska Eskimo. Color was not used. Pottery of the Upper Mississippi type has been made until recently by the Mandan Indians in North Dakota.

When we come to the Lower Mississippi district (No. 6), once the home of the advanced mound building tribes, we find a most interesting region with the greatest variety of forms yet seen, and many methods used for securing decorative effects. Here are many shapes of jars, vases, bowls and cooking-pots, and in addition, a graceful type of long-necked pottery bottle resembling in form a modern glass decanter. Here also the making of effigy forms had reached a development unsurpassed in ancient America outside of Peru. We have vessels of clay made to imitate gourds and squashes, clam-shells and even conch shells; a very popular form represented the fresh-water sun-fish or sun-perch, while another common shape imitates the bull-frog. Many other animals and birds are thus represented, and even the human form complete; while some jars represent human heads with so much character that there can be little doubt a portrait was intended.

While the use of incised decoration was common here as in most of the other districts, patterns drawn with a sharp point upon the clay while still soft, there is also a new variation, in which the designs are

scratched in *after* the vessel was fired, and the incisions then filled with red or white paint to make them stand out. This had been done on the vase shown in Fig. 5. This naturally leads us to the question of patterns painted upon the ware in color, and we find that these people made them to a limited extent, mainly in eastern Arkansas and Missouri and on the Tennessee River. White, red, yellow, and black were the colors most frequently used, and the patterns were mostly in the nature of scrolls and circles, with some angular designs, particularly in Tennessee. Seldom were more than two colors employed on any one vessel.

In some parts of this Lower Mississippi district the ceramic products show a high degree of skill and possess considerable artistic merit; so much so, that it seems a pity that the art has become extinct and has been defunct for a century or more.

FIG. 6.—Modern Pueblo Indian pottery from New Mexico, showing types of painted designs.

We now turn to a consideration of our seventh pottery district, the great Southwest, the region where native American pottery reached its highest development north of Mexico. Here we have three very distinct varieties of pottery: the first, a crude black ware with little attempt at beauty, produced by the seminomadic tribes such as the Navajo, Apache, and Paiute; the second, a more advanced two-color ware made by the more settled but still rather primitive agricultural peoples such as the Mohave and Pima, and in simpler form by the nonagricultural Indians of southern California; the third, the really remarkable pottery produced for many centuries by the tribes belonging to the Pueblo group.

And in Pueblo pottery color reigns supreme, white, black, red, yellow, and brown. Usually one color serves as a groundwork, white, red, or yellow, upon which the patterns are painted in contrasting colors. There are many types of designs, some of a purely geometric character, some conventional patterns based on the forms of animals or plants or other natural forms; some frank attempts to represent

living creatures realistically; and some of religious significance, symbols of the clouds and rain so sacred to these agricultural people, of the sacred animals associated with water, or even representations of the Katchinas, the lesser gods, themselves. A selection of modern Pueblo forms is shown in Fig. 6, and a highly conventionalized bird design may be seen in the center of the ancient Pueblo bowl shown in Fig. 7. It should be noticed here that a simple geometric pattern would result from leaving off the heads and tails of the four little birds.

FIG. 7.—Ancient Pueblo bowl from Arizona, showing conventional bird design painted on inside.

Beauty of form, as well as in color and design, may often be found in this ware; not alone in the sacred vessels of ceremonial use, and in the usually graceful water ollas, but in the food bowls, canteens, and even the humble cooking pot. Probably the pottery produced at Acoma Pueblo today combines these three elements of beauty with greater success than that of the other Pueblos; still, each has its own character and charm, and is worthy of study.

While speaking of Pueblo pottery we must not forget to state that the incised decoration so common in other regions is rarely seen here; but that a type of ware called *corrugated* did exist which is not found in other districts, a variety in which the structural coils of the vessel are left exposed on the outside to form a decoration, instead of being smoothed off, as elsewhere. Sometimes these coils are notched or modified in other ways so as to form really attractive geometrical designs. This type has not been made for many years, but the manufacture of painted Pueblo pottery is by no means a lost art; in fact, it has become a considerable source of income to the tribes which have retained it.

Such is our brief view of American Indian pottery north of Mexico; but it should be remembered that most of the Indian tribes to the south also made pottery, the ancient peoples of Mexico, Central America, the islands of the Antilles, and South America. And it should be recalled that painted pottery reached its highest development, in ancient America, among the Mayas of Yucatan, just as the modeling of life-forms attained its greatest perfection among the ancient Peruvians. But that is another story.

Reviewing the present state of ceramics among our Indians north of Mexico, we find it, among all the tribes of the east, a living art only among the Catawba of South Carolina. In the west we have the

Pueblo tribes still making pottery to a certain extent, and the art still survives among the Pimas, Mohaves, and their neighbors; also among the Diegueños of southern California. In all other regions it is dead or dying. Something should certainly be done to encourage those who are still following this truly American art, born of our own soil, and means should be taken to prevent its degeneration under the tourist demand for cheap curios.

To the Caucasian ceramic artist in search of novelties in form and color that will be distinctively American, I can freely recommend a study of Southwestern Indian pottery, ancient and modern, the ware from the district numbered 7 on the map, although this field has been drawn upon to a certain extent already. And I think he might find much to interest him in the ware from the Lower Mississippi district (No. 6) and possibly in that of the South Atlantic region (district No. 4). The other districts would probably yield little of value to him, although one concern, the Innwood Pottery in New York City, has used Iroquois forms and designs (district No. 3) to good effect.

In order to make such studies the ceramic artist should visit one or more of our great Museums, such as the Museum of the American Indian, Heye Foundation, in New York, which I have the honor to represent. It is our great aim to collect and preserve everything pertaining to the arts and customs of the original Americans, to the end that these things may not be lost, but survive to enrich the life of our America today.

Museum of the American Indian
Heye Foundation
New York City.

American Ceramic Society

1928 Annual Meeting

Ambassador Hotel, Atlantic City, N. J.

February 5-11, inclusive, 1928

The tentative program for meetings as agreed upon by the New Jersey Local Committee is as follows:

Sunday: Registration—President's Reception—Symphony Concert—Orchestra and Soloists—Dancing.

Monday: 9:30 a.m. General Session.
2:30—5:30 p.m. Division Meetings.
8:30 p.m. Dinner Dance and Cabaret.

Tuesday-Wednesday: Meetings.
Seven Divisions Simultaneously.

CERAMISTS' TOUR ABROAD

Six Weeks—May and June, 1928.

See Bulletin, page 206 this issue for description.

The Ceramic Societies of England, Germany, Czechoslovakia, and France will be hosts to American manufacturers of clay, glass, and glass enamel.

CERAMIC ABSTRACTS

Compiled by the

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[1] The abbreviation (*C. A.*) at the end of an abstract indicates that the abstract was obtained from *Chemical Abstracts* by coöperative agreement.

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Abrasives

Composition of some Indian garnets. L. L. FERMOR. *Records Geol. Surv. India*, **59**, 191–207 (1926).—Nine new analyses of garnets are given. A thin section of each sample was made and the results of the microscopic examination are utilized. The analyses confirm the presence of the molecule $3MnO.Fe_2O_3.3SiO_2$ (calderite) in garnets. The presence of the molecule $3MnO.Mn_2O_3.3SiO_2$ is also shown and the name blythite is proposed for it. A comparison is made between calculated and determined values of specific gravity. (*C.A.*)

Art

Notes on shape construction. F. H. RHEAD. *Jour. Amer. Ceram. Soc.*, **10** [6], 389–401 (1927).—The lines of development of a course for training ceramic artists, who are very much in demand, are outlined. Ceramic shape design for quantity production involves a study of factory processes, product specifications, both consumer's and factory, and manufacturing specifications. Examples of commercial designing are demonstrated, using drawings of a series of glass designs as illustrations for various points made. The filing of research studies in design, relation of shapes to product specification, and product development are discussed. The difference between the art engineer and the craftsman is pointed out.

Combining pottery and flowers for table decoration. ELIZABETH LOUNSBERY. *Arts and Decor.*, **27** [1], 40–41 (1927).—Distinctive pottery forms for flowers and for candles, and sometimes in combination, become definite items of interior decoration. Pieces correct in design, pleasing in line and glazed in the proper colors, become centers of interest in a more or less neutral room. Many illustrations are shown from the Cowan Pottery Studio revealing graceful effects achieved through modeling of flower forms and charming figures in low relief or in the round. The holders present a wide range of textures and harmonious blendings of colors often reminiscent of forests, sunrise, etc. E.B.H.

The Mexican as an expert craftsman. DOROTHY BENT. *Arts and Decor.*, **27** [1], 44–45–82 (1927).—A fascinating luminous glass but recently imported comes from Mexico. Not antique, it possesses simple form and primitive texture because made in remote mountains by methods identical in crudity with that introduced into Mexico by the Spaniards, a continued process rather than a reproduction. The craftsmen are the designers and no 2 pieces are identical, though similar. The furnace is the old Egyptian type fed with desert wood brought by donkeys. In color, the delicate sea green predominates. There is also a dark aquamarine blue. Because of imperfect technique, irregular textures and tiny bubbles appear. E.B.H.

How to choose colors for ceramic products. ANON. *Design*, **29** [1], 20 (1927).—A very interesting and useful color harmony chart is now being distributed by the Roessler & Hasslacher Chemical Co. of New York. The chart has been prepared especially for the ceramic industries, and should prove a very valuable asset to any manufacturer in whose products, color is or may be involved. This color chart of convenient size tells what colors to use and how to use them. It describes color terms, color schemes, decorating suggestions, harmony in color, in a clear interesting manner. By means of a disk wheel of colors, over 1,000 combinations of color are given. Separate charts covering overglaze and underglaze colors for pottery, tile, and clay industries, glass colors for the glass industry, and enamel oxides for the enameling industry, have been printed and are available to those requesting same. E.B.H.

Ancient potteries from the site of Rakka. JULIAN GARNER. *International Studio*, **87** [360], 52–59 (1927).—A few years ago on the site of ancient Rakka there was un-

earthed a group of unbroken Syrian bowls and urns which had very evidently been hidden with care to prevent capture by invaders. They have been determined by Prof. Sarre of the Nat. Mus. of Berlin not to belong to the primitive period, the 8th and 9th centuries including the reign of Harun al Rashid, but to the 12th and 13th centuries. R. M. Riefstahl discovered 3 types in the 7 pieces, (1) a funnel-shaped bowl having a turquoise blue glaze and the design in underglaze black, (2) a design painted on a white slip in black and cobalt blue or a greenish turquoise-blue and sometimes with dots of reddish-brown like the bolus red of some Egyptian and Turkish "Rhodus" ware; this glaze is of typical pale greenish color and is very thick, and (3) the same glaze but the design on top painted in a purplish brown manganese luster which has touches of turquoise or cobalt blue. The designs on these pieces include plant motifs going back to the Assyrian tree of life, the typical zigzag bands, magnificent whirling bands of black running diagonally, arabesque leaves and palmette flowers, conventionalized Neskhi script and medallions quite possibly heraldic. All of the pieces have holes in the foot rims which were drilled before firing showing that they were intended to be hung upon walls and looked upon from the beginning as "collector's pieces." Due to the presence of exceptionally good clays the ceramic art has always flourished in the Tigris Euphrates valley. The Assyrians used colored brick and early developed a control of color glazes which has persisted. The Sassanians from the 3rd to the 7th century preserved the traditions and yielded them to their Arab conquerors in the 7th century. Both in painted design and structural form the Near East potters have developed as no others have done, the possibilities of decoration and form in ceramic art. Design is always wonderfully adapted to curving surfaces, the surfaces are pleasant to touch with their rich glazes and the lines are entirely adapted to the clay medium giving no suggestion of evolution from metal types. The Syrian wares are made of a sandy paste generally quite solid and covered with a translucent slightly greenish glaze which if coagulated shows green drops. This glaze is a particular and charming characteristic of Rakka ware and has the peculiarity of taking on a golden or silver iridescence richer, denser, and more brilliant than on Persian ware, enhancing the preciousness, though accidental. Unlike most Near East pottery the Rakka wares present certain shapes excelling in purity of line, as the gallipot vases and some albarelli. E.B.H.

The origin and history of Capo di Monte. CHARLES HYDE-JOCELIN. *International Studio*, **87** [360], 65–71 (1927).—It is known to few students that a ware which is believed to have been translucent was produced in Italy in the 15th century. There are authentic examples of soft paste porcelains in existence made in Florence about 1590. To Charles III of Spain is due the founding of the factory of Capo di Monte, an Italian china conjuring to the imagination the spirit of Italy and to him is due its failure to survive since he took back to Spain with him 16 years later most of the skilled artists. After 2 decades the work was retransferred to Naples but was closed in 1821. The early ware is of artificial or soft variety. After the adoption of kaolin and feldspar the harder pastes were of greater utility but lost the silkiness of the soft white or creamy bodies. The designs express their love for the sea. The groups and reliefs showing mythological scenes, exhibit lifelike contours. A pronounced style is the molded and applied relief motifs. The Neapolitan artist interpreted *en camaieu* with charm. Possibly the outstanding example of the application of porcelain to interior decoration was at Portici where wall plaques, chandeliers, mirror and clock frames were of Capo di Monte. A beautiful table ware was produced bearing splendidly painted figures in medallion form on a black ground surrounded with gilt bands. The early undecorated figures of Capo di Monte, *blanc di chine*, display true artistry for they necessitated greater skill than those with colors, and were worthy of the sculptor's chisel. Collectors must beware of present day imitations from Germany, France, and Italy. E.B.H.

Two acquisitions of Chinese ceramics. S. C. BOSCH-REITZ. *Bull. Met. Mus. Art*, **22** [4] (1927).—(1) A very beautiful and unusual T'ang piece has recently been added to the Museum's collection of early Chinese pottery. It is a splendidly designed bowl in the shape of an open lotus flower, supported by 4 lions which stand on the seed-pod of a second lotus whose petals hang down and form a cup-shaped base corresponding to the upper bowl. It is very well modeled and covered with a green-brown glaze which has become iridescent in places and on the rim has almost disappeared. The beauty of the piece is due to its fine proportions and its rational well-thought-out construction. (2) Another important acquisiton shown with this one is an early porcelain vase with bold under-glaze decoration and a curious square cover. It is difficult to tell exactly to what period this should be attributed. It belongs to a family of porcelains found in tombs for which a Sung origin is claimed. This claim has not been verified because scientific excavation has been impossible in China. This vase is of a porous clay, light in weight, which is apt to fire brown-red where exposed to the heat in firing. The porcelain itself is different from the harder or more finished products of the Ming period. The glaze is of a beautiful soft texture, agreeable to the touch, very like that of the Yüan period porcelains which bear the "Shufu" mark. Perhaps it should be attributed to the Yüan period. It is an excellent example of this early ware and is a beautiful jar, with strong and well-designed decoration. A.A.A.

Survey of the Royal Copenhagen Porcelain Works. DALGAS. *Bull. Amer. Ceram. Soc.*, **6** [5], 137–42 (1927).—A historical discussion of the Royal Copenhagen Porcelain Works by the Director, taking up the various artists and technical leaders who have effected the production of the Works from the time of its founding in 1779 to the present. Each leader and his type of ware are discussed. E.J.V.

The need of a school of ceramic design in Ohio. HENRY TURNER BAILEY. *Bull. Amer. Ceram. Soc.*, **6** [5], 142–43 (1927).—Old methods of training craftsmen in design and art work are discussed. The present hope lies in professional schools. Beauty being a large factor in sales of any product which meets the conditions of use, more skilful designers must be developed. This applies to the ceramic industries of Ohio and is a big reason for the establishment of a school of ceramic design. E.J.V.

Art instruction in the potteries. H. LANDON. *Pottery Gaz.*, **52** [599], 815–19 (1927). —An address presented before the National Pottery Council at Stoke-on-Trent, on April 20, 1927. The Burslem Junior Art School is primarily concerned with the preparation of boys and girls for the artistic occupations, and fitting them to enter these occupations as apprentices. The junior art department curriculum, vocational training, manufacturers, and the classes, evening instruction, and educational visits were discussed. E.J.V.

The changing color world. GEORGE RICE. *Pottery, Glass, and Brass Salesman*, **34** [20], 141 (1926).—Interpreters and designers are giving more attention to color ornamentation of tableware than ever before. Improper use of color effects and figures is to be avoided. The laws of light and color, being important in porcelain, are discussed. E.J.V.

The determination of the tint of colored glazes on the basis of Ostwald's color theory. JOSEF WOLF. *Ber. deut. keram. Ges.*, **7** [3], 130–140 (1926).—The color measurements were made with a chrometer described by Wilhelm Ostwald in Physikalischen Farbenlehre, second edition, 1923. A series of borosilicate glazes were made up of .25 mol Na_2O, .25 mol K_2O, .5 mol B_2O_3, 2.00 mols SiO_2, and the remaining RO consisted of one of the following oxides: PbO, BaO, SrO, CaO, MgO, ZnO. In several cases .25 RO of 2 of these oxides were used in the glaze batches. The following coloring agents were added in small amounts: cobalt oxide, nickel oxide, iron oxide, manganese carbonate, chrome oxide, uranium yellow, copper oxide, lead chromate, barium chro-

mate, chrome ironstone, zinc oxide, antimony oxide, tin oxide. Most of the glazes were clear but a few were matt. The colors and tints are expressed by a series of numbers and letters as used by Ostwald. F.P.H.

A pottery built on a ranch. ANON. *Ceram. Ind.*, **8** [5], 538–39 (1927).—A description of the plant and products of the Malibu Potteries Co. A great deal of Spanish tile is made at this plant. F.P.H.

Art and the future of commerce: a plea for closer relations. A. FINCH. *Hibbert Jour.*, **25,** 422–38 (1927).—World-trade returns, especially from Asia and Latin America, indicate clearly that buyers are purchasing increasingly on quality and not quantity. France has remolded her art traditions accordingly, in order to meet postwar demands; the German "cheap and nasty" has given place to output of high artistry; Italy has reorganized on the new German model; Austria is famous the world over for her Vienna School (see *Ceram. Abs.*, **10** [2], 49 (1927)); Denmark and Sweden are undergoing an industrial art renaissance. Industrial nations must ally themselves to art, or go down. H.H.S.

Firing decorative glassware with electric heat. ODIN WILHELMY. *Elec. World*, **89,** 511–12 (1927).—Firing of decorative glass is successfully conducted in an electric kiln. A 45-kw. Hayes electric oven-type kiln was used. The load was balanced on 3 circuits (sides and bottom), with one circuit on each phase of a 220-v., 3-phase power line. Manual control was used in each circuit and the maximum rated temperature was 649°. A second kiln has a connected load of 60-kw., and operates at 220 v. Firing costs per heat and per piece in the latter case compare favorably with gas-firing costs. While the first kiln is being heated the second is being loaded and when the current is turned off one, it is started in the other. (*C. A.*)

The production of spun glass and glass figures. W. HANNICH. *Keram. Rund.*, **34,** 59 (1926).—An account of the different methods employed in Thuringia and in Czechoslovakia for the production of spun glass, various types of glass ornaments, and glass eyes. (*Jour. Soc. Glass Tech.*)

German artistic glass. W. BÜDEMANN. *Keram. Rund.*, **34,** 341 (1926).—The contemporary European output of truly artistic glass was reviewed generally. In particular, the career of Wilhelm von Eiff, Professor at the Stuttgart School of Art, was summarized, and his contributions toward the production of modern artistic glass were described. (*Jour. Soc. Glass Tech.*)

Varieties of glass painting. B. MAUDER. *Sprechsaal*, **59,** 336 (1926).—A brief account of the development of the technique of the following types of glass decoration: enamel painting, black and gold painting, transparent painting, gold painting, silver painting, red painting, and transparent surface color painting. (*Jour. Soc. Glass Tech.*)

The gilding of glass. W. HACKER. *Glas und Keram-Ind.*, **17,** 6 (1926).—Many recipes and processes for the decorating of glass with gold. (*Jour. Soc. Glass Tech.*)

The production of ornamental glasses by hand and the possibility of machine methods. W. HANNICH. *Glas und Apparat*, **7,** 106 (1926).—A description of the production of ice-glass, flashed glass, spun glass, and marble glass. (*Jour. Soc. Glass Tech.*)

The photographic production of reliefs for glass and ceramic industries. C. FLECK. *Sprechsaal*, **59,** 509 (1926).—Thirty grams of finely-cut soft gelatin were softened in 150 cc of distilled water and 10 cc of aqueous ammonia, and then 7 to 10 gm. of grape-sugar added. After warming on a water-bath, 3 cc of sepia tube dye were stirred in and finally 15 cc of 1 in 10 potassium bichromate solutions were added. The whole was filtered into a preheated measuring vessel and poured on a level piece of 10 by 15 cm. plate glass covered with 3% collodion which had been washed in acid. The edges of the

plate could be coated previously with wax to prevent the relief material from running off. The prepared plate was dried and the gelatin side marked on the edge with ink. An ordinary negative was placed with the collodion side against the prepared side of the plate and copied. The copy was placed with its collodion side on a freshly-varnished or washed glass plate and washed with water until the latter was no longer colored by chromium salts or sepia dye. It was then held in water at 20–30° and water splashed on it by the hollowed hand until the image was clear on each side. When no more sepia was dissolved in this warm water, the relief was hardened in a bath of 1 liter of water, 100 cc of aqueous ammonia, and 250 gm. of copper nitrate. A plaster of Paris cast was made, dusted with graphite and hung in a copper electroplating bath, and an electrotype mother-plate so made. If gum arabic was used in place of soft gelatin, a deeper relief resulted. (*Jour. Soc. Glass Tech.*)

BOOK

A method of creative design. A. BEST-MAUGARD. London: Alfred Knopf, 1927. Price 7*s* 6*d*. Based on 7 fundamental lines or motifs, drawn from Aztec sources in Mexico. H.H.S.

Cement, Lime, and Plaster

Plasticity of finishing limes. H. T. BRISCOE AND FRANK C. MATHERS. *Ind. Eng. Chem.*, **19** [1], 88–91 (1927).—A study of the effect of various conditions of calcination upon the plastic properties of the hydrated limes. In calcining it was found that a temperature of 1050° C to 1150° C was the most satisfactory for the production of plastic limes. The presence of certain salts such as NaCl and $MgCl_2$ increases the plasticity. The most practical method of increasing the plasticity of a dry hydrated lime seems to be to control the temperature of firing and the rate of hydration of the quicklime so that only the CaO will hydrate when the dry hydrate is formed and the MgO will be sufficiently active to react with water upon standing in contact with it for a long time. R.J.P.

The problem of the lime industry. JAMES R. WITHROW. *Ind. Eng. Chem.*, **19** [5], 550–52 (1927).—The problem of the lime industry is to produce satisfactory lime at a profit. This problem involves: (1) problems of the market and the economics, (2) problems of chemistry which can be utilized to meet the market and economic situation, and (3) engineering problems. The problems of market center about the 2 main markets, the construction trades and the chemical industry. The problem of the economics of the lime industry centers around the fact of locality and availability, the transportation to market, cost of fuel, and the handicap of abundant and cheap raw material. The problems of chemistry are mainly prevention of losses or wastage of a chemical nature and continuous control in manufacture. The engineering problems are many with those connected with calcination as the most important. R.J.P.

Present progress and future tendencies in the lime industry. OLIVER BOWLES. *Ind. Eng. Chem.*, **19** [5], 554–56 (1927).—Great progress has been made of late in lime technology. In the quarry the use of steam operated drills and smaller types is noted. Underground mining has been used by a least 12 producing companies. Kiln efficiency has been increased by better kiln design, effective insulation, better firing and agents for promoting calcination. There has been a great increase in the uses of lime until they now number hundreds. Research has accomplished much in studying the qualities and properties of lime, the temperature and time of burning and methods of hydration. Progress has also been made in the study of the problem of the plasticity of lime. The tendency of the limerock industry is for increasing fines and this tendency must be met by equipment to successfully calcine fines. R.J.P.

An X-ray study of limes having different plasticities. MARIE FARNSWORTH. *Ind. Eng. Chem.*, **19** [5], 583–88 (1927).—Use of the X-ray to study the reason for limestones of similar chemical compositions giving limes of different characteristics. A pure form of marble and precipitated calcium carbonate were fired at 1800, 2000, and 2200° F, and also in a vacuum from 1200 to 2400° F in steps of 200° F. The plasticities of the hydrates of all these samples were measured, those fired in air by the Emley plasticimeter and those in a vacuum by the Carson blotter test. The samples fired in a vacuum were found to be more plastic than those fired in air. The sample fired in air at 2000° F was not as good as the worst vacuum fired sample. An X-ray study of these samples was made. It was found that the patterns of the less plastic samples are complicated by additional lines corresponding if CaO films to strong lines of the $CaOH_2$ and $CaCO_3$ films and if $Ca(OH)_2$ films to strong lines of the $CaCO_3$ film. The intensity of these extra lines gives direct measure of the plasticity of the sample. The possibility of the presence of $Ca(OH)_2$ and $CaCO_3$ being the cause of lessened plasticity is discussed. R.J.P.

Effect of particle size on the hydration of lime. F. W. ADAMS. *Ind. Eng. Chem.*, **19** [5], 589–91 (1927).—A study of the effect of diameter of particle of quicklime, slaked with an amount of water to yield a hydrate of low moisture content, on the properties of the hydrate. Samples of lime with average diameter of particles varying from 10.0 to 0.1255 mm were hydrated. After hydration these were tested for moisture content, rate of reaction with HCl, rate of settling, plasticity, and putty volume. It was found that in hydration of high calcium lime the size of hydrate particles may be decreased by decreasing the diameter of the quicklime particles. A finely-ground quicklime will produce a more reactive hydrate possessing a lower settling rate. While a quicklime particle of 10 mm average diameter yields a hydrate with the low plasticity figure of 147 indicating an inferior hydrate, by reducing the size of quicklime particle to 5.0 mm and below, the product may be classified as a finishing hydrate, plasticity values running between 265 and 386. The putty volume is found generally to follow the plasticity figure, varying between 137 and 180 cc from 100 gms of hydrate. R.J.P.

Effect of steam on the decomposition of limestone. E. E. BERGER. *Ind. Eng. Chem.*, **19** [5], 594–96 (1927).—The rate of calcination of limestone in equal currents of air, steam, and helium was determined at increasing constant temperature 600–1000° C. The first appreciable loss of carbon dioxide from a high calcium stone occurred at one hour's heating at 600° C. The limestone was calcined at a slightly faster rate in a current of steam than in a current of air, but this was due to the effect of the characteristic physical properties of each gas in transferring heat to the sample, and not to any chemical or catalytic effect which either gas had on the limestone during the process of calcination. It is pointed out that these physical characteristics would not affect the rate of calcination in the lime kiln. R.J.P.

Rotary kilns vs. shaft kilns for lime-burning. RICHARD K. MEADE. *Ind. Eng. Chem.*, **19** [5], 597–600 (1927).—A discussion of the relative merits of shaft and rotary kilns. M. summarizes his discussion as follows: The rotary kiln is best suited for burning lime: (1) where run-of-kiln lime will meet the requirements of the market, (2) where quarry spalls, highly crystalline, and very soft limestones, shells, marl, etc., are to be burned, (3) for large outputs, (4) where operation is continuous, (5) where labor is high, (6) where fuel is cheap, where oil is obtainable as a fuel, or where pulverized coal can be used, and (7) where waste heat boilers can be installed and the surplus power so obtained employed to advantage in other operations. The shaft kiln is preferable: (1) where it is advisable to select the lime in order to secure a product that will meet the most desirable trade, (2) where the limestone is hard and compact, (3) for small operations, (4) where low first cost is desirable, (5) where the demand for

lime is likely to be variable; (6) where labor is cheap and fuel high, (7) where power is not obtainable, and (8) where dust is liable to cause a nuisance. R.J.P.

The physical behavior of gypsum plaster. FLOYD M. THORMAN. *Ceram. Age*, 9 [4], 103–108 (1927).—T. lists some of the more important industrial uses of gypsum and describes its mode of occurrence and manufacture. Plaster for different uses must have different physical characteristics. The ceramic trade in general demands a plaster that is probably the most difficult to produce. T. gives the requirements of the ideal plaster, and points out that fineness of grind and high strength are conflicting requirements. T. then gives in detail the characteristics of the plaster that is in most common use in the ceramic industries and which was developed to meet the demands of the ceramists, and describes how the manufacturing processes are controlled. A recent investigation shows that, in the use of plaster, higher consistencies give greater strength, longer life, and smoother faces. In mixing and blending the mixing vessels should be kept clean, the water should be clean, thorough blending is necessary and definite measurements should be used if uniformity is to be secured. Mixes that were agitated over 15 minutes were weak in compression due to the breaking of the newly formed crystals. Drying at ordinary temperatures is safest. Warm molds should be protected from cool drafts of air. The continued presence of moisture causes "rotting." Plaster should be stored in a dry place, and the oldest plaster should be used first even when aging is desired. Retarders and accelerators are described but are to be avoided when possible. Some competition with German plaster is being encountered, but it is inferior for reasons which T. points out. A discussion follows. A.E.R.W.

A combined gas producer and lime kiln. ANON. *Fuels and Fur.*, 5 [5], 637–38 (1927).—A description, with diagrams of a producer-kiln in operation at Heathfield, Sussex, is given. The charge consists of coke and limestone. The carbon dioxide from the burning of the coke and the limestone is reduced to carbon monoxide by coke or anthracite coal maintained at a red heat by heat from the firing zone. The amount of lime produced is about 1 lb. for 1.8 lb. of limestone and about 1.25 lb. of fuel. In addition, the kiln supplies gas to a 25 kw. lighting set. It is suggested that similar kilns might be used in steel plants where a supply of burned dolomite or magnesite is required. A.E.R.W.

U. S. Government Master Specification for cement masonry. ANON. Bur. Stand., *Circ.*, No. 321 (1927).—This specification contains requirements for a material of one type and grade only, to be used in conjunction with sand in the making of mortar for laying units of masonry construction above grade. Physical requirements are given in detail and cover: (*a*) fineness, (*b*) time of setting, (*c*) soundness, (*d*) strength; methods of tests for each are given. A note as to what constitutes rejection is given. The methods of inspection, sampling and test are covered under the following subheads: (1) temperature, (2) facilities for inspection, (3) storage of cement, (4) sampling, number and weight of samples, (5) shipment of samples, (6) times for tests, (7) treatment of samples prior to test, (8) physical tests. The method of packing and marking containers of cement is included. R.A.H.

U. S. Government Master Specification for integral waterproofing material, water-repellent type (for use with Portland cement mortar or concrete). ANON. Bur. Stand., *Circ.*, No. 322 (1927).—The materials covered by this specification are intended to be mixed with Portland cement mortar or concrete for the purpose of rendering them more completely impermeable and water-repellent. The requirements of the specifications are covered as follows: (1) types, (2) materials and workmanship, (3) general requirements, (4) detail requirements, (5) inspection, sampling, and tests, (6) packing and marking. R.A.H.

An electrical calciner for gypsum. ANON. Bur. Stand., *Tech. News Bull.*, No. 120, p. 4 (1927).—In the commercial calcination of gypsum the procedures followed by

various manufacturers differs widely, particularly in regard to temperature and time of calcination. An apparatus used by the Bureau in an investigation of this phase of gypsum technology has been replaced by a larger and improved model to meet the demands for this experimental work. A description of this apparatus is given.

R.A.H.

Operating results of the constant temperature humidity box for the storage of cement test specimens. ANON. Bur. Stand., *Tech. News Bull.*, No. 120, p. 4 (1927). —The temperature of this box does not vary more than 1° from 70° F for the most severe operating conditions when the doors are being opened for the reception of specimens for observation. Humidity seldom drops below 93%, and operates constantly at 97%. Some observations are made as to the effect of the circulating water on the temperature and humidity when compared to air circulation. R.A.H.

French tests on alumina cement concrete shows study needed. ANON. *Eng. News Rec.*, **98** [17], 684 (1927).—Abstract of an article appearing in "Le Genie Civil" by E. Freyssinet. Some of peculiarities of concrete made from alumina cement are noted. Differences of structure are quite pronounced with spots of quite sound material and others the reverse with differences in color corresponding. Some tests were made using sea water for gaging in comparison with fresh water with results in favor of the latter. It is essential not to use alumina cement under conditions where the materials or the final mix are heated beyond the normal heat applied to concrete. R.A.H.

Gypsum tile from synthetic calcium sulphate. ANON. *Rock Prod.*, **30** [8], 45 (1927).—A description of the plant and products of the Calumet Chemical Company. F.P.H.

Lime receives prominence at meeting of nation's chemists. ANON. *Rock Prod.*, **30** [9], 42–50 (1927).—A symposium on lime at Richmond meeting of American Chemical Society. The following papers are abstracted: (1) "The Problem of the Lime Industry," J. R. Withrow; (2) "The Consumer, the Market, the Lime Business, and the Chemical Industry," Charles Warner; (3) "Progress and Future Tendencies in the Lime Industry," Oliver Bowles; (4) "Bridging the Gap between Research and Profits in the Lime Industry," W. E. Carson; (5) "Some Variables Affecting the Behavior of Limes Used in Causticizing," J. V. N. Dorr and A. W. Bull; (6) "Analysis of Lime," J. M. Porter; (7) "Lime in the Paper Industry," P. A. Paulson; (8) "Use of Lime in Water Softening and Water Purification," Charles P. Hoover; (9) "Use of Lime in Butter-Making," O. R. Overman; (10) "Lime Problems in the Beet Sugar Industry," R. W. Shafor; (11) "Rôle of Lime in Tanning," George D. McLaughlin; (12) "Lime in the Treatment of Pea Canning Wastes," L. F. Warrick; (13) "An X-ray Study of Lime Hydrates Having Different Plasticities," Marie Farnsworth; (14) "Effect of Particle Size on the Hydration of Lime," F. W. Adams; (15) "High Temperature Whitewash," E. P. Arthur, W. B. Mitchener, and J. R. Withrow; (16) "Burnt Lime and Raw Lime in the Basic Open-Hearth Process," C. H. Herty; (17) "Effect of Steam on the Decomposition of Limestone," E. E. Berger; (18) "Rotary Kilns *vs.* Shaft Kilns for Lime-Burning," R. K. Meade; (19) "Science and Engineering in Lime Burning," V. J. Azbe; (20) "Needs and Future of Lime in the Chemical Industry," J. H. Withrow. F.P.H.

Thermal analysis of plaster. ANON. *Compt. Rend.*, **148**, 202–204 (1927); *Rock Prod.*, **30** [9], 76 (1927).—The thermal analysis of plaster is carried out in a special apparatus designed by P. Jolibois and L. Chassevent: a truncated, conical brass vessel surrounded by a calorimeter jacket containing water, the temperature of which is electrically adjusted. The vessel holds the plaster, a thermometer being so placed that it dips into the mass. Control and classification on industrial plaster, according to their respective rate of hydration, can be obtained through this apparatus by measuring the beginning of the set, the rate of transformation into gypsum, the composition, and

resistance. There are given, in explanation of the process and apparatus, curves showing the temperature rise during setting, and the time for a number of different plasters.

F.P.H.

Effect of the calcination process on the properties of Portland cement (*continued*). E. ULLRICH. *Zement*, **9**, 165–70, **10**, 181–184 (1927); *Rock Prod.*, **30** [9], 76 (1927).—Two mixes each of 46 g (corresponding to 28 g of clinker) were calcined in electric furnaces and their heating period of calcination and rate of cooling carefully observed. A standard Portland cement mix and mix high in iron oxide were used. A platinum foil and a silicon-carbide resistance furnace were used. The former permitted temperatures up to 1500° C; the latter was used for temperatures up to 1400° C only. The temperature was measured by means of a platinum-rhodium thermocouple calibrated by a Siemens and Halske galvanometer. The 2 clinkers were crushed in a mortar and then ground in a porcelain ball mill. The iron oxide clinker required much less time to reach the desired fineness of 10% retained on the 4900-mesh seive; this seems to prove that it is more brittle than Portland cement clinker, though harder than the latter. The cements were tested at 24 hr., using Kuhl's apparatus for testing of small cement specimens. A 6-gm sample of cement was mixed with 18 gm of sand of definite grading with the addition of a constant quantity of 11% water. The mortar was mixed one minute. The sand was a standard sand passing 225- and retained on 900-mesh per sq. cm sieves (about 40- and 75-mesh, American). The specimen dimensions were 30x10x10mm. They were tested in accordance with standard procedure for tension and compression at ages 3, 7, and 28 days. Each value was the average of 4 tests. Multiplying the bending strength obtained by this method by 2 gives the tensile strength; multiplying by 30, the compressive strength. Supplementary tests were made of the change of color of the clinker when cooled at sintering temperature. It was found that 1275° C was a critical temperature below which cooling resulted in black clinker, while above it the clinker was brown. This temperature may, therefore be regarded as the beginning of a reaction between CaO and Fe_2O_3 resulting in the formation of calcium ferrites. The effect of temperature of calcination was studied at temperatures of 1175 to 1500° C. The jump in strength of mix 1 (Portland) between 1250 and 1275° C is quite noticeable. At 1275° C the values are almost double those at 1250° C, after which they remain almost constant. At 1275° C the clinker had a light yellow color. The normal greenish black color made its appearance only at 1400° C. The mix with high percentage of iron oxide yielded negligible strength at 1275° C. Only at temperatures above the latter could some rather low strengths be determined. Its hardness increases as that of Portland cement. The color of this clinker is in general darker. At 1300° C it already appears dark gray; the clinker sintered at 1400° C assumes a dead black color. The effect of period of sintering on strength was studied in another series. The mixes were sintered at 1400° C under identical conditions for periods of 20 min., 3 hr., 6 hr., and 12 hr. The results of 28-day tests are indicative of the variations. Portland cement clinkers cooled normally have a definite maximum at 6 hr.; this maximum is reached at 3 hr., when the clinkers are cooled suddenly. It must be emphasized that rapid cooling does not always improve the quality of cement. The iron oxide mix shows considerable improvement by sudden cooling after 20 min. sintering. Further sintering results in a reduction of strength. It is notable that in this series hardness increases parallel to strength, contrary to the first series of tests. The effect of rate of cooling on strength was studied under 3-hr. heating, 20-min. calcination period, and varying periods of cooling to 500° C. Upon sintering 20 min. the clinker was taken from the furnace and exposed to air. A 5-hr. cooling period was thus achieved, reproducing conditions of a shaft kiln. Portland cement shows best strengths for medium rate of cooling of 96 min., while the iron oxide mix yields highest values for sudden cooling. Hardness seems to increase through

sudden cooling. Accordingly, the strength of a cement is less a function of temperature of calcination and more that of calcination period. Further tests were made prolonging calcination to 3 and 6 hr. An actual rise in strength was thus recorded, which was in part superior to that observed in the first series at temperatures of 1300° C. Decomposition of the clinker was observed in all cases. Comparing this work with Kuhl's assumptions, we find the explanation: the carriers of the hydraulic properties of Portland cement are isomorphic mixtures of solid solutions of $3CaO \cdot SiO_2$ with $3CaO\ Al_2O_3$ or $8CaO\ 2SiO_2Al_2O_3$. The extent of the solution determines the hydraulic properties of the clinker. F.P.H.

Fineness of Portland cement and its effect on the rate of hydration. ALBERT HAUENSCHILD. *Zement*, 453–56, 469–71 (1926); *Rock Prod.*, **30** [9], 60–62 (1927).—H. draws the following conclusions from his investigations: (1) hydration is the result of the action of water on the surface of the cement particles. The rate of hydration increases with rapidly increasing surface area of decreasing sizes. (2) Cement particles of 15 to 18μ hydrate completely, *i. e.*, nearly all the clinker minerals become altered. Coarser particles hydrate only in part. (3) The rate of hydration depends also on the properties and chemical composition of the clinker minerals. Alite hydrates considerably faster than the other clinker minerals. (4) The rate of hydration depends also on the size of the clinker crystals. A single crystal of 15μ diameter hydrates more rapidly than a particle of similar size made up of different clinker minerals. F.P.H.

The mineralogy of several calcium aluminates occurring in aluminum-cement clinker. C. W. CARSTENS. *Zement*, **15**, 335–38 (1926).—The optical constants of $CaO.Al_2O_3$ and $3CaO.5Al_2O_3$ are given, agreeing with those observed by Rankin and Wright. (*C. A.*)

A study of magnesium oxychloride cement with X-rays. TUTOMU MAEDA. *Sci. Papers Inst. Phys. Chem. Research* (Tokyo), **5** [73], 95–102 (1926); 5 figs (in Esperanto).—To determine the crystalline or amorphous state of the particles in hardened Mg oxychloride cement, M. used the X-ray powder method on cement with a large proportion of solid, on cement with a large proporiton of liquid, on $2MgO.MgCl_2.12H_2O$ with some $MgCl_2$ solution on $Mg(OH)_2$ with some $MgCl_2$ solution and on MgO. In hardened cement the oxychloride certainly exists in crystalline state. $Mg(OH)_2$ is probably also present in an imperfect crystalline state, but lines of MgO were not found. That constituents of hardened cement are found in the crystalline state does not confirm the LeChatelier theory, for crystals can exist at colloidal dimensions. (*C. A.*)

The aqueous vapor pressure of magnesium oxychloride cement, and the state of water in it. TUTOMU MAEDA. *Sci. Papers Inst. Phys. Chem. Research* (Tokyo), **5** [75], 133–40 (1926); 3 graphs. (In Esperanto.)—The vapor-pressure isotherm of Mg oxychloride cement (1 specimen rather solid, 1 rather liquid) was measured at 25°, a modified Smith isoteniscope and modified procedure being used. The curve for the more solid cement indicates that the vapor pressure is determined by a definite hydrate, believed to be $3MgO.MgCl_2.12H_2O$; that for the less solid cement appears to be chiefly a capillary phenomenon. Multiplication of crystals, *i. e.*, increase of the solid part of a cement, while necessary to hardening, causes brittleness when unaccompanied by solution or surface hydration. "Sweating" on the surface of a cement is caused by a comparatively low vapor pressure and a compact surface, which hinder the absorption of moisture. (*C. A.*)

PATENTS

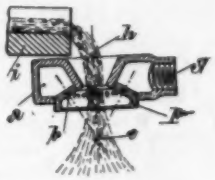
Artificial stone or marble. L. E. WELCH. U. S. 1,626,577, April 26, 1927. A composition of matter of the character described comprising the reaction product of magnesium oxide and a filler mixed with an aqueous acetic acid including liquid com-

position containing magnesium chloride and zinc sulphate in substantially the proportions that would result from mixing substantially $1\frac{3}{8}$ gallons of substantially 2.1 specific gravity zinc sulphate solution with 100 gallons of 1.8 to 2.4 specific gravity magnesium chloride solution, the proportion of liquid composition being sufficient to wet the magnesium oxide.

Process of manufacturing slag cement. J. G. HARDING. U. S. 1,627,237, May 3, 1927. The herein described process of manufacturing slag cement, which consists in mixing a variable lime content with upward of 70% of undried granulated slag and 3% or less of gypsum, thoroughly drying the mixture and completing the mixture by adding cement clinker approximating 5% or more and thereafter grinding the mixture to extreme fineness and simultaneously mixing the ingredients.

Plastic cementitious material. H. E. BROOKBY. U. S. 1,627,952, May 10, 1927. A plastic cementitious material comprising substantially 88 parts by weight of hydraulic cement, 6 parts of finely divided plastic clay and 6 parts of finely divided hydrated lime.

Method and means for the treatment of slags by fluids under pressure. M. MAGUET. U. S. 1,627,982, May 10, 1927. An apparatus for granulating molten slag, comprising an annular member, means for causing a solid stream of molten slag of substantially circular cross-section to fall freely through the member along the vertical axis thereof, the member having means adapted to direct streams of fluid on the stream of molten slag and converging on a point on the axis of the falling stream below the means, and means for conveying fluid under pressure to the fluid directing means.



Improved shaft lime-kiln. ANON. Brit. 245,653; *Rock Prod.*, **30** [8], 93 (1927).—Air is admitted into the kiln through the wall or centrally, the air flues being provided with dampers. The vents open into the combustion zone and also into the calcining zone, the air before admission to the kiln being preheated in flues provided in the kiln wall. F.P.H.

Molded magnesite articles. K. ERDMANN. Brit. 258,731; *Rock Prod.*, **30** [8], 93 (1927).—Fibrous materials and magnesite cement (Sorel) are heated together at a temperature of about 180 to 220° F until the hardening is completed. Heating is best carried out in electrically heated apparatus or in airtight chambers through which the materials are conveyed on belts, etc. F.P.H.

Catalyst for hydraulic cements. ANON. Brit. 262,294; *Rock Prod.*, **30** [8], 93 (1927).—Calcium chloride (calcined) to which may be added lime or calcium sulphate as a retarder, is mixed with sufficient silicic acid to make a solid product suitable for storage. F.P.H.

Rotary cement kiln. VICKERS, LTD. AND L. D. PARKER. Brit. 262,525; *Rock Prod.*, **30** [8], 92 (1927).—The rotary kiln shell is extended beyond the discharge end and ports placed in the extension wall, through which the calcined cement material passes to a number of smaller rotary coolers surrounding and rotating with the main shell. The discharge end of the coolers are open and outgoing material cooled by the incoming air. Baffles are placed over the open ends to prevent material falling out of any of the cooler sections where it is above the furnace. F.P.H.

Preparation of cement raw materials for rotary kiln process. I. E. LANHOFFER. Brit. 263,221; *Rock Prod.*, **30** [8], 92 (1927).—Raw cement materials are crushed and made into slurry which is squirted in narrow strips on to a conveyer running in heated chamber. The strips are partially cut through so that upon delivery to a rotary drum the strips break up into small spherical fragments. These are dried at low temperature,

heated and fed into a rotary kiln. Better fuel ratio is said to result from the use of the small uniform fragments of dried slurry.

Rotary kiln. J. H. BENTLEY. Brit. 263,630; *Rock Prod.*, **30** [8], 92(1927).—One or more conical sections are placed in various positions along the length of a rotary cylindrical kiln. The base of the cone may be equal or greater than the kiln diameter and its position lies toward the feed-end of the kiln. The angle between the axis of the cone and its side is greater than the inclination of the kiln to the horizontal. Internal lifters are provided to lift the material from the conical section to the cylinder section, and other lifters oppositely inclined are provided in the conical section to increase the delay of material held there. F.P.H.

Unsintered hydraulic cement. ANON. Ger. Pat. 440,795; *Rock Prod.*, **30** [9], 76(1927).—Clay or claylike material is mixed with dry burnt lime or wet hydrated lime and the resulting mixture ground fine. The mixture is calcined at a temperature below the sintering point and the calcined material ground to the fineness of cement. The process admits the use of oil shale as a source of fuel and clayey material. F.P.H.

Aluminous cements. E. MARTIN. Brit. 251,618, April 30, 1925. NaCl 2.5–5% or similar quantities of other suitable alkali metal salts, $CaCl_2$, CaF_2, fluorspar or cryolite are added to the raw materials of aluminous cements to facilitate the production of hydraulic compounds. A cement may be formed of bauxite 100, limestone 100 and NaCl 5–10 parts. (*C. A.*)

Manufacture of alumina-containing cements. G. HERTZKA. Brit. 265, 494, Oct. 5, 1926. Raw materials for aluminous cement manufacture in a comparatively coarse state of division (leaving a residue of 1% on a sieve 900 meshes/cm.^{2}) are shaped into briquettes etc., which are preheated for 24 hrs., and then maintained for 30 hrs. in a state of rest at a temperature between 1150° and the melting point of the mixed materials, the clinker produced being cooled over a period of 30 hrs. before grinding. (*Brit. C. A.*)

Enamels

Some observations on the aging of enamels. H. G. WOLFRAM AND R. H. TURK. *Jour. Amer. Ceram. Soc.*, **10** [5], 334–38(1927).—The tendency toward more rapid production of enameled ware has reduced to a minimum the time allowed in most plants for aging of enamels. Aging of the enamel slip allows the clay to become thoroughly slaked, absorb the larger enamel particles, and thus prepare it for its cohesion to the metal base. Aging or soaking of the clay before use is an excellent substitute for part of the time consumed in aging the enamel slip. Observations of results obtained in commercial application of enamels has lead to the following conclusions: (1) Enamels should be aged before use in order to gain the full benefit of the adsorption properties of the clay and enamel colloids. (2) If the proper time of aging of enamels cannot be allowed at least the clay should be brought to a fine state of subdivision by aging or soaking in water. (3) If aging is not allowed in some form, the enamel usually is not as easily applied with the ordinary handling encountered in average production. (4) If aging of the clay is allowed there is a quicker turnover of the stock enamel in the mill room.

Note on the solubility of enamel frit in mill water. H. L. COOK. *Jour. Amer. Ceram. Soc.*, **10** [5], 339–43(1927).—Methods of determining the solubility of enamel frit in mill water are outlined. Various tests tried show that (1) solution increases, as fineness increases, (2) mixing has little or no effect upon solubility, (3) variation of smelter treatment has little or no effect upon solubility, and (4) Na_2O and B_2O_3 will dissolve from a dry ground frit proportionately to the fineness thereof.

Observations upon the effect of various electrolytes when added to enamel suspensions made with and without clay. H. L. COOK. *Jour. Amer. Ceram. Soc.*, **10** [5],

344–46(1927).—The literature is reviewed. The effects of various electrolytes on a clay slip, an enamel slip, a finely ground clay-sand-water suspension, and a finely ground sand-water suspension were observed. "Setting up" of water suspensions of finely divided insoluble materials seems more dependent on fineness of grinding and degree of solution of the suspended material than upon the presence of clay.

Enamel symposium. F. G. JAEGER, R. D. COOKE, ROGER FELLOWS, AND A. JENNINGS. *Jour. Amer. Ceram. Soc.*, **10** [6], 451–56(1927).—I. The effect of manganese dioxide on the physical properties of ground coat enamels is: (1) to give a good gloss; (2) to give a harder enamel; (3) to reduce the coefficient of expansion of the glass in which it is used; (4) when used with cobalt a uniform color desirable in stove work is obtained; (5) no difference in the adhesion of the ground coat between enamels using manganese, cobalt, or combinations of dioxides is apparent; (6) no effect on chipping is apparent; (7) while not absolutely essential in ground coats it is very desirable for use from an economy stand point. II. A theory of ground coat adherence based on the fact that part of the steel is oxidized to iron oxide which is partly absorbed by the fused enamel and into which some of the enamel penetrates is set forth, and an explanation given of various effects obtained. III. Most of the things which should be done to maintain control in making and firing of ground coats for sheet steel are emphasized. IV. The method of control for application of ground coat enamel by weighing the amount of dry enamel on a sheet of metal of known area is described. This is used to maintain a uniform consistency of the enamel. Other essential features which have in the past caused trouble to many enamelers are mentioned.

The necessity for operating standards and procedure control in the enamel industry. ROBERT D. LANDRUM. *Bull. Amer. Ceram. Soc.*, **6** [5], 121–32(1927).—A thorough discussion of all the various items in the enamel industry which must be checked as to operating standards and procedure control. These include uniformity in gage of the iron, composition of the iron, design of the black shape, annealing, dies, lubricant, condition of shapes, preparation for enameling in cleaning of the ware, extent of pickling, specifications as to composition and fineness of raw materials for enamel frit, storage of raw materials, weighing and mixing the batch, smelting, quenching, storage of enamel frit, milling of the enamel, storage and aging of the wet enamel, preparation of the enamel for application, drying, firing, and inspection. E.J.V.

Control testing of borax and soda ash stocks used in the smelting of enamel frits. W. V. KNOWLES. *Bull. Amer. Ceram. Soc.*, **6** [5], 132–34(1927).—A simple method for routine control of borax and soda ash involving the installation of a few pieces of chemical apparatus in the mixing room is submitted. By titration of a solution containing known weights of the materials to be controlled it is possible to determine the percentage of the dry material and of the moisture contained therein, making it possible to rectify the weight introduced into the batch so as to allow for the moisture. E.J.V.

What causes common defects in castings? J. W. BOLTON. *Foundry*, **55**, 357–60 (1927).—Blowholes and pinholes are always caused by gas, which may come from the iron, or from the sand, or may be entrapped during pouring of the castings. To eliminate blowholes, melting conditions must be correct, wet ladles must be avoided, the sand must not be too wet, and must have sufficient permeability to carry off the generated steam rapidly. M.E.M.

Microscopic investigation of opacity phenomena in enamel frits. A. OTREMBA. *Keram. Rund.*, **34**, 67–70, 88–90, 107–109(1926).—It was found that in order to opacify enamel frits with fluorspar it is important to have alkalis and Al_2O_3 present. They probably produce Al and alkali fluorides in the frit. That alkalis are important in the production of opacity was shown when borax was substituted for KNO_3 which resulted in frits having poorer opacity. Increasing the fluorspar content in frits increases the

refractoriness. Natural cryolite is superior to fluorspar for opacifying frits. For example, it is not necessary to introduce alkalis and Al_2O_3 along with the frit in order to obtain opacity with cryolite because they are already in this mineral. Furthermore, with fluorspar opacity is first obtained by heating the frit to 950°C whereas with cryolite this is obtained at 750°C. Artificial is better than natural cryolite for opacifying enamels. H.G.S.

An intermittent fired enameling furnace. ANON. *Fuels and Fur.*, **5** [5], 649–50 (1927).—A description is given of a recently installed, intermittently fired, enameling furnace used in the manufacture of enameled ice-boxes. The furnace is fired from the rear directly into the working chamber, all of the combustion gases passing to the front of the furnace and then through vents in the floors to the flues leading to the recuperators and stack. This arrangement permits the use of low pressure, air-type burners, and direct and immediate absorption of the heat by the most effective, re-radiating surfaces takes place. Deep wells and pits into which the ware may fall are eliminated and compensation is made for the cooling effect caused by the opening of the door. Purging to produce an oxidizing atmosphere is accomplished positively with the door closed by injecting a charge of clean, preheated air under pressure from the recuperator. Another feature is a power-operated door of unique design. Automatic devices control all of the operations aside from the handling of the charging fork, the main air-control valve for the door, and the hand wheel control of the rotary mechanism controlling all the firing operations of the furnace. Combustion is very rapid and extremely high flame temperatures are maintained. A.E.R.W.

Special acid-resisting enamels. WALTER KERSTAN. *Ceram. Ind.*, **8** [5], 570–74 (1927).—Formulas are given for special acid resisting enamels. High silica and alumina, boric acid, and zinc oxide are conducive to good acid-resisting enamels. A special cooling is necessary to prevent the appearance of hairlines. The trend of acid-resisting enamels is toward the composition of Jena chemical glass ware. An electrical method for testing the porosity of enamels is described. Tests to determine the resistance that enamels offer to chemical action are described. F.P.H.

Refractory acid-resisting enamels. ANON. *Ceram. Ind.*, **8** [5], 576–78 (1927).—The author points out the value of annealing the metal. The castings should be painted with acid before sandblasting. The casting should be cleaned with filtered high pressure air before they are enameled. Formulas are given for ground and cover coat enamels. F.P.H.

BOOK

Technologie chimique des matières premières de l'émail. JULES GRÜNWALD.—Translated from the 2nd revised and enlarged edition by Helene Hirsch and Marcel Thiers. Paris: Dunod. 316 pp.; 40 francs +40%, bound 48 francs +40%. Reviewed in *Rev. prod. chim.*, **30**, 45–46 (1927). (*C. A.*)

PATENTS

Enameling metal articles and the like. C. NOEL. French Pat., 609,844, May 5, 1924.—The articles are treated with a current of air while the portion to be enameled is raised gradually to a suitable temperature. (*Brit. C. A.*)

Enameling brass or like metal. R. A. AUGER. Brit. 251,327, Jan. 27, 1925. Brass water taps or like articles of similar yellow metal are electroplated with Cu; this is deposited slowly, heated to expel any gases in the coating and then coated with a vitreous enamel. (*C. A.*)

Coating aluminum or magnesium or their alloys with silicates. S. DANIELS, A. C. ZIMMERMAN, AND J. A. WATSON. Brit. 252,070, Feb. 16, 1925. Heat treatments before and after coating with silicate solutions are described for providing a permanent coating which renders the metal impervious and protects it from corrosion. (*C. A.*)

Glass

The frosting of glass by mixtures containing hydrofluoric acid and alkali fluorides. C. D. SPENCER AND L. OTT. *Jour. Amer. Ceram. Soc.*, **10** [6], 402–410(1927).—In this paper a number of experiments are described confirming the protection theory of acid frosting. A description is given also of an etching cell by means of which it is possible to observe, through a microscope, the initial stages and the progress of events during the acid etching of glass surfaces. A theory of the fortification or strengthening of abraded and acid-etched surfaces is proposed and illustrated.

Stained glass windows, colored sunlight. CHARLES J. CONNICK. *Amer. Mag. Art*, **8** [5], 240–48(1927).—This fascinating craft is still fresh and youthful though between 800 and 1000 years old. C. reverts to the original type of stained glass for windows, using transparent glass accented by paint lines, simple design, and symbolical terms rather than the realistic effects achieved by the American school through the use of opaque or opalescent glass with the quality of paintings on canvas. The first impression of a stained glass window should be related to jewels or flowers in sunlight, emotional rather than intellectual. Large areas of leaded white or clear glass enriched with medallions in splendid color, have a superb decorative effect made more significant by the meaning of the designs. Stained glass may be made a great expression of spiritual verities when designed and made by one craftsman-artist, or with helpers, but can never reach real distinction under factory rules. E.B.H.

Developments in glass technology during recent years. G. W. MOREY. *Chem. Met. Eng.*, **34,** 230–32(1927).—As the most important developments in the industry M. lists the following: bottle machines, automatic feeders, machine blowing of window glass, direct production of flat sheet glass, and continuous rolling of plate glass. In the chemical field, the development of Pyrex, many colored glasses, lead-free bulb glass, and glass transparent to ultra-violet light are most noteworthy. M.E.M.

Researches in glass at Mellon Institute. E. WARD TILLOTSON. *Chem. Met. Eng.*, **34,** 232(1927).—Lists the subjects and the investigators. M.E.M.

Sheet and plate glass industry makes rapid progress. J. W. CRUIKSHANK. *Chem. Met. Eng.*, **34,** 233–34(1927).—Traces the development of automatic machinery in the industry. M.E.M.

Displacement of labor by machinery in manufacture of glass is outlined. ANON. *Amer. Glass Rev.*, **46** [31], 15(1927); *Glass Ind.*, **8** [5], 110–15(1927); reprinted from *Monthly Labor Review* of the U. S. Bur. of Labor Statistics.—An exhaustive investigation giving pertinent facts and data regarding the revolutionary change caused by machinery in making glass. E.J.V.

Small compact leer offered as efficient annealing unit by Simplex Engineering Co. ANON. *Amer. Glass Rev.*, **46** [32], 17–18(1927); *Nat. Glass Budget*, **42** [53], 5(1927).—A description of the new Simplex ME leer, as to construction details and operation. E.J.V.

The preparation of mirror surfaces. MAX KALLENBACH. *Diamant*, **47** [36], 772–74(1925); reprinted from *Centr. Ztg. für Optik und Mechanik.*—The preparation of glass surfaces for silvering, methods of silvering, and the degree of reflection are discussed. E.J.V.

Thorn-Prikker and his religious glass windows. J. Z. *Diamant*, **48** [1], 5–7(1926).—A discussion of the famous stained glass windows in various churches made by Johann Thorn-Prikker. E.J.V.

The coating of mirror glass with silver. The silvering of large mirrors. C. R. DAVIDSON. *Diamant*, **48** [1], 8–10(1926); reprinted from *Centr. Ztg. für Optik und Mechanik.*—The silvering of large mirrors is described. Compositions of solutions used in the process are given and the entire process of silvering is taken up in detail. E.J.V.

The freezing and coating of show windows. ANON. *Diamant*, **48** [1], 12–13 (1926).—A discussion of the freezing and coating of show windows with frost, etc., and methods of treating the surface with various solutions to prevent it. E.J.V.

Stained glass as banquet hall decoration. ANON. *Diamant*, **48** [4], 63–66 (1926).—A description of stained glass windows used in banquet halls, and other places for festivities as decorations. E.J.V.

Variegated glass windows in the Middle Ages. JOHN A. KNOWLES. *Diamant*, **48** [4], 68–69 (1926).—A discussion of many-colored glass windows of the Middle Ages and their production. E.J.V.

Middle Age methods for the application of cartoons by use of colored glasses. J. A. KNOWLES. *Diamant*, **48** [5], 86–88 (1926), **48** [6], 106–109 (1926).—A description of the methods of using sections of stained glass to form different designs, pictures, and cartoons by varying arrangements of the pieces, somewhat after the fashion of jig-saw puzzles. E.J.V.

Endeavors for modernization in the Russian glass industry. M. W. S. JACOPSON. *Diamant*, **48** [5], 92 (1926); **48** [6], 112 (1926).—An account of the introduction of modern methods and glassworking machinery in Russian glass plants. E.J.V.

Somewhat about glass decolorizing materials. W. H. *Diamant*, **48** [7], 126 (1926).—The glass decolorants may be divided into 3 groups; (1) those acting as decolorants due to their optical properties, as manganese dioxide, nickel and cobalt compounds, antimony, and antimony compounds, (2) those acting as decolorant due to their chemical action, arsenic, and saltpeter, and (3) those which combine the actions of the other two, as manganese dioxide and arsenic, or manganese dioxide, antimony, cobalt oxide, and arsenic, etc. The use of these various types is discussed. E.J.V.

Assyrian glasses of 2500–3000 years ago. H. S. *Diamant*, **48** [10], 186 (1926).—A discussion of the work of the English savant, Dr. Thompson, on Assyrian glasses dating back to 700 B.C. The principal ingredients used by the Assyrians were the same as those of the present day, alkali, quartz, and lime. Different colored glasses were produced by the Assyrians and it is evident that they understood the production of any color glass. Ruby glass was produced by them by the addition of 32 parts of zinc oxide, 20 parts of antimony, and 1 part of gold to 7200 parts of glass batch. E.J.V.

Quicksilver application in the mirror industry of Fürth. I. K. H. *Diamant*, **48** [11], 203–205 (1926).—The methods used in the factories at Fürth in silvering their mirrors are described in detail and their development is traced. E.J.V.

Glass paintings in the art museums at Basel. H. H. *Diamant*, **48** [12], 227–29 (1926).—A description of various stained glass masterpieces of the Middle Ages to be seen in the museums at Basel. E.J.V.

Differences between English and foreign glass stainers in the 16th century. J. A. KNOWLES. *Diamant*, **48** [8], 143–46 (1926), **48** [9], 169–70 (1926).—A historical discussion comparing the art of the English and foreign glass workers of the 16th century. Various outstanding artists of the period and their works are discussed. E.J.V.

Introduction of the pneumatic glassblowers patent pipe in the glass industry. ANON. *Diamant*, **48** [8], 146–47 (1926).—The advantages of the pneumatic blow pipe over the old-fashioned glass blowers pipe are pointed out and its greater use in the glass industry is urged. E.J.V.

Nonsplintering safety "Kinonglass." N. KINON. *Diamant*, **48** [8], 151–52 (1926).—A description of "Kinonglass," a triplex safety glass produced by the welding together of two outer layers of glass with a 3rd layer of transparent, tough, and clear material. Its applications are enumerated. E.J.V.

Stained glass windows in the Nuremburg Gothic churches of St. Sebald and St. Lorenz. H. H. *Diamant*, **48** [10], 183–86 (1926).—A description of the various stained glass windows in the churches of St. Sebald and St. Lorenz in Nuremburg. E.J.V.

The transition from the mosaic to the melt method in glass staining. JOHN A. KNOWLES. *Diamant*, **48** [13], 246–48 (1926), **48** [14], 266–68 (1926), **48** [15], 286–88 (1926).—A thorough discussion of stained glass art in all countries of Europe, taking up the work of various artists, to show the gradual transition in methods of producing stained glass windows, etc. E.J.V.

The colored glass windows of Stephaneum at Aschersleben. ANON. *Diamant*, **48** [14], 263–65 (1926).—Discussions of the work of Stephaneum in stained glass six centuries ago, by various scholars, are presented. E.J.V.

The Czechoslovakian glass industry would make itself independent of Hohenbocka glass sands. ANON. *Diamant*, **48** [14], 265 (1926).—The exploitation of fine glass sand deposits in Vondracka near Mala Skala is expected to emancipate the Czechoslovakian glass industry from its dependence on the Hohenbocka sands. E.J.V.

A new German-Belgian glass factory. ANON. *Diamant*, **48** [15], 283–84 (1926). —A description of the new plant of the German Libby-Owens Co. for the mechanical production of glassware in Gelsenkirchen-Rotthausen. E.J.V.

The history of stained glass in South Germany. H. H. *Diamant*, **48** [2], 23–25 (1926), **48** [3], 43–45 (1926).—A discussion of examples of stained glass produced in S. Germany, starting with that of one Andreas in the 13th century. Churches, etc., are cited where this glass may be seen. E.J.V.

The silvering of glass and quartz filaments. ROBERT S. WHIPPLE. *Diamant*, **48** [2], 26–27 (1927); reprinted from *Centr. Ztg. für Optik und Mechanik*.—The solutions and methods used in silvering glass and quartz filaments are described. E.J.V.

Annealing of glass. M. THOMAS. *Glastech. Ber.*, **4** [9], 323–32 (1926).—The problem of annealing glass is very thoroughly discussed and explained. Under development of a rational strain releasing and cooling process are discussed the origin of strains, connection with the viscosity, lower limits of the annealing range, discussion of the origin of strains by cooling from different initial temperatures, the existence of a proper annealing temperature, and methods for the determination of the proper annealing temperature. The dependence of the proper annealing temperature on the composition of the glass is taken up under systematic test melts for determination of this connection, effects of the individual glass batch components on the proper annealing temperature, and generalizations of the results and applications to glasses of any composition. It is shown that a proper annealing temperature exists for every glass and that a close approximation of this temperature may be made based on the results of systematic research. E.J.V.

Glass as a building material in reinforced concrete. OTTO GRAF. *Glastech. Ber.*, **4** [9], 332–39 (1926), **4** [10], 373–79 (1927).—The use of glass for floors and skylights in reinforced concrete structures is described and discussed. Tests conducted on the suitability and strength of glass as a building material in reinforced concrete at the Materials Testing Laboratory of the Technische Hochschule at Stuttgart are discussed. E.J.V.

Determination of the soluble alkali in ground glass. ERNST FISCHER AND WALTER TEPOHL. *Glastech. Ber.*, **4** [4], 137–42 (1926).—Mylius' method of determining the soluble alkali in glass by heating a tube filled with neutral water at 80°C for 3 hours and titrating the resulting solution with n/100 HCl to determine the alkali (as Na_2O) dissolved per dm^2 of surface is described. The classification of glasses according to this method is as follows:

Hydraulic Class	Alkali (as Na_2O) dissolved in mg/1000 from 1 dm^2 glass surface
1. Water-stable glasses	0–15
2. Resistant "	15–45
3. Hard apparatus "	45–150
4. Soft apparatus "	150–600
5. Defective "	over 600

To supplement Mylius' test, investigations were made in which glass was ground to pass 0.30 mm screen and remain on a 0.15 mm screen. The dust was carefully screened and washed out and then 1 cc of the ground glass was heated for 3 hours at 80° in a tube filled with neutral water and the solution titrated for alkali (as Na_2O). The classification of glasses according to this method is as follows:

Hydraulic Class	3 hours at 80°C mg/1000 Na_2O from 1 cc ground glass
1. Water-stable glasses	0–60
2. Resistant "	60–120
3. Hard apparatus "	120–500
4. Soft apparatus "	500–1200
5. Defective "	over 1200

A comparison of the 2 tests is made by trying both on various glasses. E.J.V.

Work flow in the glass industry. K. H. SCHMIDT. *Glastech. Ber.*, **4** [11], 401–20 (1927).—Work flow is defined as "an orderly, progressive, temporally determined continuous sequence of work operations." As economic preliminary conditions for work flow, standards and types, specialization, and equalization of seasonal and market fluctuations are discussed. The advantages of work flow, work investigations as preliminary steps for work flow, and raw material handling, largely by machinery, are taken up. Work flow in shaping takes up bottle glass, plate glass, and mirror glass as different branches in the industry where it is applicable. It is pointed out that in Ford's River Rouge plant 475 workmen produced a much greater quantity per man than did 1200 men at the National Plate Glass Co. plant, pointing out the advantage of work flow in the former as against the lack of it in the latter. Work flow in shipping and other less important operations is also discussed. E.J.V.

Future trend in plate glass manufacture. II. The pot method. GEORGE E. HOWARD. *Nat. Glass Budget*, **42** [52], 3 (1927).—Advantages and disadvantages of the pot method are discussed. Particulars in which the system may be improved and the effect of each are enumerated. An analysis is made of the pouring and rolling operation, using sketches to clarify points brought up. Annealing the pot method plate and grinding and polishing are also discussed. **III. The continuous tank system.** *Ibid.*, **42** [53], 3 (1927).—Two methods of ribbon flowing in commercial use are the accumulating method, commonly called the "Ford Process," where the flow from a relatively narrow and thick stream of hot glass is spread laterally to the plate width upon a large roller and the plate made by a smaller or sheet forming roll, and the slot method, where relatively colder glass is flowed through a thin slot or orifice having a width substantially equal to the plate width, then passed through 2 equal-sized forming rolls, which determine final thickness. Both are capable of improvement. The advantages and disadvantages of both systems are enumerated. Several of these factors are discussed in greater detail. **IV. The continuous or car system of grinding and polishing.** *Ibid.*, **43** [1], 3 (1927).—The difference in the grinding and polishing operations is pointed out. The polishing action consists of 7 things, which are listed. The evolution of grinding and polishing is taken up. The evolution of the polishing machine is traced, pointing out the important elements in proper polisher design and operation. Different types of polishers are discussed, their good and bad features being pointed out. The ideal polisher of the future is described. E.J.V.

Development of the Amco unit leer is described. ANON. *Nat. Glass Budget*, **43** [1], 3 (1927).—The continuous open-fired leer, the raw producer gas-fired muffle leer, and the Amco "C" type leer are described as earlier developments. The adaptability of the "C" leer to ware feeding is discussed. The Amco unit leer developed in 1921, its performance, and the reasons for its development are taken up in detail. E.J.V.

Recent progress in the glass industry. W. E. S. TURNER. *Pottery Gaz.*, **52** [599], 824–28 (1927).—The economic aspects of the glass industry are dealt with, the distri-

bution thereof throughout the world, employees in various countries, and a census of production given. The war had much influence on the condition of the glass industry in England, Germany, Austria, etc. The introduction of automatic machines, which have been developed to a great extent in the last quarter century was important and the influence of research has been very pronounced, particularly in regard to improvements in furnaces and refractories. Data on production of electric lamp bulbs, bottles, and window glass by machines is presented. The manufacture of high grade chemical glassware is also discussed. English and American institutions carrying on scientific research are enumerated. E.J.V.

Temperature measurement in glass furnaces. G. GEHLHOFF AND M. THOMAS. *Glastech. Ber.*, **4** [6], 210–19(1926).—The usual methods of measuring temperatures in glass furnaces are with the thermoelectric pyrometer, the optical pyrometer, or the total radiation pyrometer. Data is presented showing: (1) the effect of the flame upon the temperature measurement; (2) measurements in various places in the glass furnace; (3) measurements in various places in the pot; (4) measurements in a pot furnace during melting; (5) temperature measurements in tanks. E.J.V.

The economic development of the glass industry in the Rhineland since antiquity. BRUNO KUSKE. *Glastech. Ber.*, **4** [7], 249–60(1926).—A discussion of the Rhenish glass industry covering the period from the Middle Ages to the present. E.J.V.

On the fining of pure and aluminous alkali-lime-silica glasses with sulphates or arsenic. E. ZSCHIMMER. *Glastech. Ber.*, **4** [8], 281–86(1926).—The use of arsenic and sulphates as fining agents in glass is discussed. Experiments were conducted using a pure alkali-lime-silica glass, and batches in which 1, 2, 3, 6, and 12% alumina were introduced at the expense of the silica. Results show: (1) that additions of sodium sulphate of 0.1–0.5% cause the formation of a foam on the glass at 1400–1450°C, while with too high a sulphate addition the glass is apt to run over due to excess foaming; (2) the tendency to foaming and running over of the melt, at constant temperatures, increases with the alumina content when sulphates are used; (3) additions of about 0.8% arsenic (with 1% Na_2O as saltpeter) causes a harmless foaming at 1400–1450°C, but too great an addition of arsenic (about 2%) produces a strong foaming and running over; (4) without a doubt all glasses in the series tested melt clear with arsenic and saltpeter quite easily, while with sulphates it is more difficult and at times impossible to do so. A heat treatment scheme for use with sulphates is presented and the theory on which it is based is discussed. E.J.V.

The full automatic fuelless annealing device. ANON. *Glass Ind.*, **8** [5], 103–105 (1927).—The development of annealing devices is traced. A new completely automatic, continuous annealing device which eliminates all extra parts for stacking ware and which consumes no fuel while in operation, has been in commercial operation for the past 7 months at the bottle plant of the Peerless Glass Co., Long Island City, N. Y. The device automatically takes the ware directly from the forming machine while it is in a hot or semiplastic state and places it in the annealing chamber before strains have developed, obviating the necessity of reheating. The heat in the ware as it comes out of the mold is conserved and the ware passes through a generous soaking or equalizing period and is subjected to a gradual, regulated cooling process. Though no fuel is used in the annealing operation the annealing chamber must be ready at the proper temperature for receiving the hot ware from the machine molds at the moment that blowing is resumed after a cessation of operation. For this purpose 2 small gas burners are provided and the preliminary heating is accomplished by means of a muffle chamber built over the soaking section just back of the stacking device. No flame enters the annealing chamber. The burners are used only for maintaining a temperature of 800°F in the idle annealing chamber on Sundays and are in operation only during the weekend shut down

and for about an hour after the machine is started on Monday morning. The details of construction and operation are rather fully described. The device is the invention of Orie Shackelford and was developed by John Mayo, both of Fairmont, W. Va.

E.J.V.

Manufacture of light-diffusing glasses. J. B. KRAK. *Glass Ind.*, **8** [5], 109–10 (1927).—The development of light-diffusing glasses for illuminating glass ware is traced. A large class of glasses which diffuse light on account of their inherent properties, besides those in which light diffusion is caused by frosting or sand blasting of the surface, is the nontransparent, opaque, alabaster or opal glasses. These terms are all poorly defined and include fairly opalescent glasses, those that are translucent by transmitted light and opaque by reflected light, and glasses which appear opaque by both reflected and transmitted light. An ideal light diffusing glass should diffuse a bundle of parallel light rays without any losses due to reflection or absorption, and should be such that it appears to be giving off light itself. There are three kinds of opacity, (1) one which causes reflection of the light rays, (2) another which causes refraction of the light rays, and (3) one which causes bending of the light rays. In the majority of opal glasses all 3 effects are taking place at the same time. The effect of the minute particles causing opacity (whatever they may be) depends not only on their number, but also on their size, and on their way of being grouped together. These elements depend largely on temperature conditions and on the length of time of exposure of the glass to heating. Proper temperature control and careful furnace management are just as important as maintaining the proper chemical composition of the batch. Materials for producing opacity include, magnesium silicates, such as talcum and asbestos, phosphates, such as bone ash, calcium phosphate, and sodium phosphate, tin oxide, titania, zirconia, and fluorides, such as cryolite, fluorspar, sodium silico fluoride, and barium fluoride. Fluorides, most widely used of opacifying materials, will only give satisfactory results when used in conjunction with alumina. Cryolite, a double fluoride of sodium and aluminum, is the ideal opacifier for this reason. Both natural and synthetic cryolite is used, but due to its high cost it is often completely replaced by a mixture of fluorspar and feldspar. E.J.V.

Clarksburg's glass industry. ANON. *Nat. Glass Budget*, **43** [2], 17 (1927), reprinted from *Clarksburg Telegram*.—Various glass plants in the vicinity of Clarksburg, W. Va., are described and discussed. These include plants of the Hazel-Atlas Glass Co., Rolland Sheet Glass Co., Eagle Convex Glass Co., Weston Glass Co., Columbia Glass Co., and the Louie Glass Co. E.J.V.

Over twelve million bottles annually. ANON. *Ceram. Ind.*, **8** [5], 551–54 (1927). —A description of the bottle factory of the W. T. Rawleigh Co. F.P.H.

Glass machinery savings enormous. ANON. *Ceram. Ind.*, **8** [5], 555–62 (1927).—A comparison of quantity of production of modern machine processes with old hand processes. Machines increase bottle output per man 41 times over old process. Over 2000 electric bulbs per hour per machine are now made. Fourcault process cuts labor cost nearly 70% over hand process. F.P.H.

Portable unit leer. ANON. *Fuels and Fur.*, **5** [5], 657 (1927).—A short description of a new portable unit leer for the annealing of glass articles. An extension of the heating element enables the ware to travel at two or three times the ordinary rate and yet receive the proper time and temperature conditions essential to proper annealing. An ingenious application of the old-time, "squirrel-tail" flue over the leer enables the ware to be delivered to the packer slightly above room temperature regardless of the rate of production. The light, woven-wire, belt conveyer operates entirely within the leer, thereby saving additional fuel. No expansion joints are used. Accessory devices are easy to install. The complete unit is compact, simple to operate and self-contained.

A.E.R.W.

The durability of some soda-lime-magnesia glasses. ANON. *Fuels and Fur.*, **5** [5], 586(1927).—An abstract of a paper by V. Dimbleby and W. E. S. Turner. It was concluded that the gradual molecular substitution of magnesia for lime produced the following effects: (1) durability toward boiling water was slightly enhanced, (2) resistance to attack by boiling hydrochloric acid was slightly impaired, (3) resistance offered to the action of boiling caustic soda solution was somewhat decreased.

A.E.R.W.

Physical studies in lamp and valve manufacture. C. C. PATERSON. *Engineering*, **123**, 252–54(1927).—Occluded glass-gas, mostly H_2O and CO_2, comes off so persistently and at an undiminished rate when a bulb is heated at 360°C for weeks, that it looks as if gas diffuses through the glass into the bulb. This problem remains unsolved. The gas from the metal (W&Mo) filament and support, chiefly H and CO, is easily extracted, but an air-film one molecule in thickness would raise gas pressure to 0.1 mm. A coating of red P and cryolite on the filament traps the gas mols. by condensing on the glass; the condensation being caused by the change red P→white P→red P.

H.H.S.

Modern glass mixtures. O. LECHER. *Continental Eng.*, **1**, 50(1926).—In producing copper ruby glasses, the following important points had to be considered: (1) The glass mixtures used should not be too hard, much better results being obtained with soft batches containing lead. (2) The amount of copper used should be limited. Experiments had shown that much less difficulty was encountered in the production of ruby glasses containing 0.2–0.8% of cuprous oxide than in the use of old formulas with copper contents of 2 to 5, or even 25% Cu_2O. Perfect reduction of these large amounts of cuprous oxide was very difficult, so that quite frequently blue copper oxide glasses were obtained. (3) Solution of the cuprous oxide was materially improved by the addition of about 2% of borax. (4) Chemically pure cuprous oxide only should be used together with liberal amounts of reducing agents such as stannous chloride, sodium tartrate, stannic oxide, etc. (5) A slightly reducing atmosphere should be maintained. (6) Melting should be effected at high temperatures, which should be kept up for a comparatively long time in order to assure uniform absorption of cuprous oxide by the glass. (7) In some cases, remelting of the glass and, eventually, addition of fresh amounts of reducing agents, might prove necessary. (8) Cooling off too quickly often produces light yellow to orange colored glasses, the ruby color being developed gradually by annealing. Methods of producing copper ruby glasses were given together with the following batches:

	Batch I	Batch II	Batch III	Batch IV	Batch V
Sand	100 kg	100 kg	100 kg	100 kg	100 kg
Limespar	12	30	15	14	—
Potash	31	—	—	20	25
Soda ash	2.7(98%)	35	33	12	—
Borax	0.5	9	3	8	15
Cuprous oxide	150 gm	4	1.5	0.3	2.5
Copper sulphite	—	—	—	—	—
Sodium sulphite	200 gm	—	—	—	—
Sodium tartrate	400 gm	2	0.5	0.45	—
Potassium nitrate	—	4	—	3	4
Iron oxide	—	1	—	—	0.2
Stannic oxide	—	4	2	0.15	5
Selenium	—	—	—	0.14	—
Red lead	—	—	—	—	25
Manganese dioxide	—	—	—	—	2.5

Batch I, hard glass; Batch II, a soft glass free from lead suitable for flashing; Batch IV, garnet-red; Batch V, rich in lead and particularly suitable for flashed glass. (*Jour. Soc. Glass Tech.*)

A contribution to the history of lamp working in the Thuringian woodlands. E. LÖBER. *Glas und Apparat*, **7**, 17 (1926).—A general historical article. (*Jour. Soc. Glass Tech.*)

A tank furnace having direct firing with crude oil. I. SCHUR. *Glashütte*, **56**, 284 (1926).—During the war period, some glass factories in South Russia converted their furnaces into oil firing. Direct firing was especially suitable for small works as it needed no steam-raising or air-compressing plant. A small furnace which had been built recently in South Russia after the experiences obtained from several such furnaces was described and illustrated. Its capacity was 8 metric tons, and its normal output 3 tons per 24 hours, although by working three 8-hour shifts 4 tons could be obtained. In the latter case, the glass was not quite plain, but was good enough for ordinary bottles. The average oil consumption was 0.4 kg. per kg. of glass drawn out. The oil was conveyed to the furnace in pipe of 25 mm. bore, the supply being regulated by ordinary valves, and it flowed into the furnace through ordinary funnels of fire clay. Experiments were made with specially shaped funnels, but no advantages resulted, since any ridges or small openings soon became coated over with carbon. The oil fell onto a sill leading into the furnace from the top of the air regenerator, and burnt with the air without the formation of soot. A deposit of very hard carbon formed on this sill and had to be removed with the aid of good steel bars and heavy hammers every 2 or 3 weeks. Recuperators could have been used to heat the air for combustion, but regenerators were simpler, cheaper, were easily changed, and required no specially shaped materials. (*Jour. Soc. Glass Tech.*)

The viscosity of aqueous solutions of the silicates of soda. V. R. MAIN. *Jour. Phys. Chem.*, **30**, 535 (1926).—Values obtained for the viscosity of a solution of sodium silicate, as determined by an instrument of the Ostwald type, were lower than those obtained in one of the variable pressure type. Viscosity-concentration curves were given and exhibited the properties of lyophile sols, while the slope of the viscosity curve at a given concentration was dependent on the $Na_2O:SiO_2$ ratio, being greater for the solutions richer in SiO_2. The addition of silica to caustic soda solutions resulted in an increase in viscosity, slow at first, but much more rapid as the proportion of silica was increased above the ratio $Na_2O:SiO_2=1:2$. The actual increase in viscosity for a given change of ratio was dependent on the concentration. The relationship between temperature and viscosity was linear; the temperature coefficient was affected by the $SiO_2:Na_2O$ ratio, being higher for a greater proportion of silica. Solutions containing less silica than was represented by $Na_2O:SiO_2=1:2$ were considered to be, at normal concentrations, mostly noncollodial. For higher proportions of silica, a solvated colloidal aggregate was formed, its size and characteristics depending on the $Na_2O:SiO_2$ ratio and on the concentration. (*Jour. Soc. Glass Tech.*)

Postwar apparatus glass. H. THIENE. *Keram. Rund.*, **34**, 199 (1926); from *Z. angew. Chem.*, **39**, 193 (1926).—Many of the post-war glasses were imitations of Jena pre-war glasses or of the Pyrex glass. Resista glass was very seedy. The compositions and the coefficients of linear thermal expansion, α of glasses of the Pyrex class were:

	Pyrex %	Silex %	Vulkanit %	Resista 1923 %	Resista 1925 %
SiO_2	80.5	77.9	81.5	81.4	75.3
Al_2O_3	2.1	0.8	2.8	2.0	2.5
B_2O_3	11.8	14.1	11.0	10.6	15.8
Na_2O	4.4	4.1	3.7	4.4	3.4
K_2O	0.2	2.3	0.9	1.1	1.0
CaO	0.4	0.8	0.3	0.7	—
Sb_2O_3	—	—	—	—	1.3
As_2O_3	0.7	—	—	—	—
$\alpha\times10^7$	39	43	37	40	36

The thermal resistance of Resista glass measured by heating a bulb filled with mercury and then plunging in water at 20°, was 240° compared with 230° for Jena 20. The resistance of these 2 glasses against boiling water and 2 *N* sulphuric acid was practically the same, but the loss in weight of the Resista after boiling for 6 hours in 2 *N*-caustic soda was 21.50 gm per sq. cm, compared with only 10.56 gm for the Jena 20. Moreover, the Resista glass gave up appreciable amounts of antimony to any alkaline solutions after only a short heating. Hence in such glasses the coefficient of expansion had been reduced at the expense of the resistance towards alkalis. The Jena works before the war had produced glasses having much lower coefficients than those of imitations, and even in 1912 frying pans and baking dishes were made (*e.g.*, out of Duraxglas). The chemical compositions and coefficients of expansion of these Jena glasses showed that the Jena glass works could truly claim priority in the production of heating glassware or of glasses with low coefficients of expansion:

	SiO_2 %	Al_2O_3 %	B_2O_3 %	Na_2O %	K_2O %	MgO %	CaO %	BaO %	Sb_2O_3 %
Tempax	75.4	1.6	17.5	3.6	0.4	—	0.1	—	1.6
Supremax 1565^{III}	57.4	3.2	23.6	1.9	0.5	8.7	4.7	—	—
Durax 3817^{III}	75.6	5.6	14.3	3.3	0.4	—	0.1	—	0.4
Geräteglas 20	75.3	6.2	7.6	5.7	0.8	—	1.1	3.5	—

The coefficients of linear thermal expansion were: Tempax, 36×10^{-7}; Supremax, 35×10^{-7}; Durax, 31×10^{-7}; and Geräteglas 20, 49×10^{-7}. Other new Jena resistant glasses were Geräteglas (apparatus glass) 16 and Geräteglas 10 (1447^{III}). (*Jour. Soc. Glass Tech.*)

The volatilization of sodium fluosilicate. A. OTREMBA. *Keram. Rund.*, **33**, 343, 364 (1925).—The experiments were made in a small furnace and the temperatures measured by Seger cones and pyrometers. The carbonates employed were effective in reducing volatilization of fluorine, but calcium carbonate could not act until it commenced to dissociate. Quartz, feldspar, and clay, when used singly, gave similar results. Dissociation was not complete in any case at 1000°. Tests with borax and boric acid were abnormal because of the possibility of decomposition of some sodium fluoride from the sodium fluosilicate, and its volatilization as borofluoride. (*Jour. Soc. Glass Tech.*)

Precipitations of metals from glass melts. L. SPRINGER. *Keram. Rund.*, **34**, 503 (1926).—S. cited the following cases of deposition of metals from glass melts and of experiments with metallic iron in molten glass: (1) Precipitations of irregular light gray pieces of metal occurred in a factory producing lead glass. The deposition must have been caused by improper furnace conditions, and proved to be pure lead with a trace of iron. (2) Very porous pieces of metal precipitated from a copper ruby melt consisted of $\frac{2}{3}$ copper and $\frac{1}{3}$ tin. Bubbles the size of a pea clung to the metal. (3) Precipitations from a copper ruby melt were found to consist of 67% copper and 30% iron. Probably ferrous oxide had been used as a reducing agent. (4) Some round pea-sized, yellowish-white, metallic lumps found in a piece of perforated pot bottom were found to consist of silver alone. (5) A black piece of metal the size and shape of a cigar and a small white metal spangle were precipitated from a window glass melt. The factory authorities diagnosed them as silver from the silver-containing cullet. Investigation showed them to contain but a trace of silver, the black piece consisting of copper and iron, while the spangle was iron alone. The origin of these was a mystery. (6) A square piece of alleged cast iron introduced intentionally into a pot of pale metal after 3 melts, appeared as dark gray, irregularly-shaped, melted metal. A chemical test showed the latter to be chiefly iron, but to contain a small quantity of copper. In the same melt, a screw retained its shape. (7) Some cigar-shaped precipitations,

2 cm long, surrounded by many large bubbles, which gave off yellow streaks in some pale metal, were proved to consist of 90% copper and 10% iron. A sphere of 1 cm diameter was found in the bottom of the same pot. (8) A piece of cast iron and a conglomerate of cast iron and wrought iron were both found to have melted after 4 days in a pot. Yellow streaks tailed off from them and they were associated with bubbles, mostly with the cast iron. A piece of iron weighing 65 gm lost 80% of its weight after 6 melts. The bubbles might have been due to the decarbonization of the iron. The yellow coloration imparted to the glass and the loss in weight with the last sample showed that the iron was oxidized, but it was not known from where the oxygen was was derived. The lower melting-point of cast iron caused easier melting. (*Jour. Soc. Glass Tech.*)

Glass pockets in regenerative pot furnaces. E. S. *Sprechsaal*, **58,** 840(1925).—The article gave the advantages and disadvantages of various types of glass pockets. The ideal pocket had not yet been found. (*Jour. Soc. Glass Tech.*)

The measurement of the light transmission of rough-cast glasses. ANON. *Sprechsaal*, **59,** 333(1926).—A suitable apparatus for the measurement of the relative light transmissions of glasses used for sky- and side-lights consisted of a cylindrical chamber painted neutral gray internally. At one end was placed the sample to be tested, and at a distance of 125 mm from it was a frame holding a piece of sensitized paper. All exposures were for an equal period, namely 35 minutes, to a subdued daylight, the paper afterward being fixed under standard conditions. The method was employed to illustrate the relative transmissions of the following glasses: (1) direct action of subdued daylight, 100%; (2) smooth or lightly ornamented glass (irregular surface outside), 88%; (3) lightly ornamented glass (decoration inside), heavily ornamented and "matt" glass, up to 70%; (4) wired glass, 55%; (5) ornamented wired glass, about 50%. The smooth glass was 5 mm in thickness. (*Jour. Soc. Glass Tech.*)

Heat recovery for economic glass melting. H. BARTH. *Sprechsaal*, **59,** 189(1926).—A general nonmathematical article. Of the 4 tanks mentioned in Table I the better efficiency of No. 4 compared with No. 1 was mainly due to the greater volume of regenerators per unit area of tank surface. The inferior results of No. 3 compared with No. 2 were due to incorrect or insufficient setting of the checkers in the horizontal chamber of No. 3, which were not filled to the top, and hence much of the gas and air and also of the waste gases passed over the chequers instead of through them. The data for Nos. 4 and 5 showed the influence of heat recovery on furnace efficiency and economy. Table II, giving data for 2 furnaces melting window glass, showed the effect of the degree of preheating on the temperature attained and hence on the furnace efficiency. Quick melting meant good glass and low fuel consumption. (*Jour. Soc. Glass Tech.*)

A new strain tester for glass. W. EWALD. *Sprechsaal.*, **59,** 413(1926).—A strain tester has been evolved by the Askania-Werke employing the principle of a concave black glass plate as polarizer. The brightness of the field was increased by the use of a condenser in the observation tube, and a mica plate insured a suitably colored field. (*Jour. Soc. Glass Tech.*)

A new strain viewer. W. EWALD. *Sprechsaal*, **59,** 597(1926).—The instrument was of the type which depends on the use of polarized light for revealing strain in glass. Its novel features were: (1) a large field, (2) an intense source of illumination which enabled strain to be detected in filled or unfilled bottles as well as in colored or uncolored bottles, (3) a metal body allowing the examination of hot objects, and (4) the inclusion of a camera which could be used to substitute or augment visual observations. (*Jour. Soc. Glass Tech.*)

On the aging of thermometer glasses. L. HOLBORN AND J. OTTO. *Z. Instr.*, **46,** 415 (1926).—Experiments were conducted to determine the most suitable treatment for artificially aging thermometer glasses. The test pieces used were 25 cm long and 0.8 cm in diameter. These were alternately heated and cooled in an electrically heated tube furnace 55 cm high and 9 cm in diameter. The expansion was measured during and after heating by comparison with a quartz tube mounted in the furnace. The results of tests on various glasses showed that effective aging of the glasses could be most readily obtained by heating the completed thermometer for about 3 hours at a temperature of about 20° or 30° above the lower limit of the critical range (*i.e.*, the range in which the rate of expansion of the glass is greatest). Thereafter the glass was cooled in about the same length of time, to a temperature just below the softening point, and maintained at that temperature for 6 hours. The rate of cooling from that temperature to room temperature had little influence on the subsequent alteration of the zero point of the thermometer. Examples were given of several thermometers made of Jena glass 59 III and treated in the above manner, which, after many years' service, showed very little alteration of the zero point. (*Jour. Soc. Glass Tech.*)

On the tarnishing of optical glasses. H. HEINRICHS. *Z. Instr.*, **46,** 424 (1926).—In the method proposed by Heinrichs and Tepohl for determining the weathering properties of optical glasses, it was assumed that the tendency of such glasses to tarnish could be quantitatively measured by determining the equivalent weight of the "typical" oxide dissolved from the glass when acted on by weak acetic acid. This assumption was justified by the fact that the results obtained by means of the test applied to various types of glasses agreed with the behavior of similar glasses in actual use. H. gave such further details of the method as were necessary to enable other workers to make strictly comparative tests. The method was recommended as being particularly suitable for use in connection with the production of optical glasses, since it provided a ready means of determining the durability of newly-melted glasses, and also gave an indication of the direction in which advances might most easily be made in the production of new glasses. (*Jour. Soc. Glass Tech.*)

A peculiar case of color change and luminescence in glass. F. ECKERT. *Z. tech. Physik*, **7,** 301 (1926); *Glasindustrie*, **34,** 348 (1926).—Alkali- and boric acid-containing glasses, with small amounts of cerium, turned brown under the action of ultra-violet light (or daylight) and also gave the bright blue fluorescence and phosphorescence of the same color. X-rays, on the other hand, did not cause any coloration; also all oxides of heavy metals appeared to prevent the color change due to X-rays when present in sufficient concentration. The brown coloration of cerium glasses was diminished by heating. (*Jour. Soc. Glass Tech.*)

A few recent absorption glasses. G. JAECKEL. *Z. tech. Physik*, **7,** 301 (1926); *Glasindustrie*, **34,** 349 (1926).—It was necessary to classify transparent glasses according to their behavior in ultra-violet light, their absorption, or their transmission values. No data were supplied about the composition, but the absorption values of yellow glasses and the comparability of these with regard to the fluorescent color were given. This property was attributed to the size of the coloring colloidal particles. (*Jour. Soc. Glass Tech.*)

Apparatus for measuring the turbidity of opalescent glass. W. EWALD. *Z. angew. Chem.*, (*Chem. App. u. Maschinenw.*), **40,** 32 (1927).—A photometer is described in which the proportion of light that passes through the glass (*a*) directly, (*b*) in a diffused condition, and (*c*) the proportion that is scattered by diffuse reflexion may be determined. Parallel beams of light from a common source are passed through 2 tubes of colloidal thorium oxide solution arranged at an angle to each other, and the issuing light is reflected from mirrors on to a photometer head on which the light passed by 2

glasses, one a standard and the other that under test, placed one at the beginning of each tube, is compared. The light diffused by passing through the glass is compared by means of a second photometer placed between the 2 tubes, so that light diffused from each glass at an angle of 40° with the incident beam is measured. Reflected diffused light is measured in a similar way when the glasses are placed at the other end of the thorium oxide tubes. (*Brit. C. A.*)

Relation between size, capacity, and heat consumption of glass tank furnaces with regenerative firing. W. FRIEDMANN. *Arch. Wärmewirtschaft*, **8**, 59–62(1927).—F. constructs, on the basis of a questionnaire, a series of charts showing the production, and useful and actual heat consumption, per sq. m. of tank area, in present German practice. (*C. A.*)

Gas-heating of pot furnaces in glass works. H. XHYGNESSE. *Chaleur et industrie*, **8**, 42–47(1927).—Description and discussion of the operation of this type of glass furnace bringing out its advantages over the Boetius furnace, together with a heat balance for a gas furnace provided with Sauvageot gas producer. (*C. A.*)

The relative efficiency of Pyrex glass and metal condenser tubes. J. T. LITTLETON, JR. AND H. C. BATES. *Trans. Amer. Inst. Chem. Eng.*, **17**, 95–106(1926).—Measurements were made of heat transfer rates of the following: (1) clean Cu tubes, (2) Cu tubes heated in air at 550° for 1 hr. to oxidize the surface, (3) Shelby steel tubing, and (4) Pyrex glass tubing. The results indicate, in curves, that the surface film resistance is practically the controlling factor in metal condenser tubes and that volume conductivity has very little effect. While Cu has about 6 times the conductivity of steel it condenses only 10% more steam, which may be due to the smoothness of the Cu surfaces and the absence of scale, for when Cu was oxidized the condensation value dropped below that of the steel. Cu with a conductivity more than 300 times that of glass condenses but 2.5 times as much steam for the more rapid rates of flow. Discussion brought out that oxide films should be removed from the inside of the metal tubes, and that the drop in efficiency is largely due to adhesions. Tubes may drop to 25% of the expected value and a good average is 50%. (*C. A.*)

Power losses in commercial glasses. W. C. DECKER. *Elec. World*, **89**, 601–603 (1927).—The dielectric constants, phase differences, and power losses of 11 common glasses were investigated. Least power loss was shown by borosilicate glasses containing no heavy metals and but a small quantity of alkali. Next in order were the Na–Pb borosilicates, then the Na–Pb silicates and finally the Na–Ca silicates. At 1000 to 30,000 cycles per sec., Pyrex B was found to have the minimum power loss. Pyrex B has a small temperature coefficient of capacitance and conductance and is therefore especially useful for purposes where it is necessary to avoid changes in capacitance and conductance with changes in temperature. The dielectric constants for the 11 glasses vary in value from 4.7 to 8.7 at 1000 cycles per second and from 4.7 to 7.9 at 30,000 cycles. This variation is attributed mainly to differences in the compositions of the glasses. The absence of heavy metals and large amounts of alkalis from a borosilicate, as in the Pyrex glasses, lowers the dielectric constant to a minimum. Details as to methods of testing, etc., are given. (*C. A.*)

BOOK

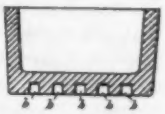
German Faience Culture. EDUARD FUCHS AND PAUL HEILAND. *Diamant*, **48** [4], 69–70(1926).—A review. E.J.V.

PATENTS

Casting table. H. R. SCHUTZ. U. S. 1,625,164, April 19, 1927. A casting table comprising an underframe and a top portion having a plurality of interengaging con-

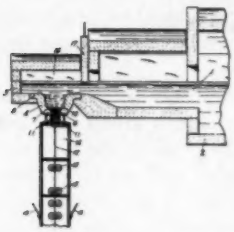
nections, with a part of the connections preventing relative movements of the underframe and top lengthwise of the table, and a part permitting such relative movements lengthwise of the table and preventing the same in any other direction.

Pot for glass-melting furnaces. G. STEIN. U. S. 1,625,435, April 19, 1927. Pot for glass-melting furnaces which consists in that the underside of the bottom is arranged with open grooves or passages running parallel from edge to the opposite edge of the pot.



Apparatus for shaping glassware. R. W. CANFIELD. U. S. 1,625,590, April 19, 1927. A press mold for making glass blanks for pastemold glassware, comprising a mold body of carbon material having sufficient thermal conductivity to mold molten glass without sticking thereto.

Glass. F. M. LOCKE. U. S. 1,626,042, April 26, 1927. A borosilicate glass batch containing an alkali metal nitrate and a relatively large percentage of silica.



Forming sheet glass. J. C. BLAIR. U. S. 1,626,382, April 26, 1927. The method of forming sheet glass, wherein glass flows downwardly through an elongated orifice, whose end portions are narrower than the central portion.

Drawing sheet glass. J. P. CROWLEY. U. S. 1,626,395, April 26, 1927. An apparatus for producing sheet glass, comprising an endless metal belt, supporting means for the belt including a stationary water-cooled table within the belt loop having a flat horizontal upper surface supporting the upper run of the belt, polishing means acting on the outer surface of the belt during its lower run, a metallic water-cooled roller having a polished surface adjustably mounted above the upper run of the belt, means constantly feeding a stream of molten glass upon the upper polished surface of the belt, and means for driving the belt to draw the glass from the stream under the roller and carry it away in sheet form.

Sheet-glass-drawing apparatus. J. L. DRAKE. U. S. 1,626,396, April 26, 1927. In sheet glass apparatus, a draw table including a plurality of links closely associated to provide a substantially solid surface and a plurality of spaced links arranged alternately with the closely associated links.

Machine for making bottles or other articles of glass. A. MCNISH. U. S. 1,626,548, April 26, 1927. A machine for making bottles or other articles of glass of the character described, comprising a support, a table mounted for rotatable and vertical sliding movement on the support, a plurality of parison and blow molds mounted on the table, means for effecting a gathering of glass in the desired parison mold, coöperative clutch members mounted respectively on the table and on the upper part of the support, and valve controlled pressure operable means for raising the table on the support to effect engagement of the clutch members so that the table may be partially rotated when elevated.

Fabricating glassware in suction-fed molds. K. E. PEILER. U. S. 1,626,575, May 3, 1927. Glass-working apparatus comprising a body mold, means for producing suction in the interior of the mold, a charge-severing knife associated with the mold, a bottom mold adapted to close the charging end of the mold after charging, and a pressing plunger arranged to close the opposite end of the mold during charging and to thereafter enter the mold to press the glass therein.

Machine for deforming glass articles. H. D. MADDEN. U. S. 1,626,683, May 3, 1927. A glass-working machine comprising means for producing a restricted heat zone, means for continuously moving a tubular body through the heat zone whereby heat is applied to a portion of the tubular body, means for varying the length of the

heated portion to alter the caliber of the heated portion and means for discharging the altered tubular body from the machine.

Apparatus for forming glass. L. D. SOUBIER. U. S. 1,626,702, May 3, 1927. In a glass forming machine, the combination of separate molds arranged to receive charges of glass simultaneously, and separate means provided in duplicate coöperating with the molds for concomitantly forming the charges of glass into finished articles by a series of operations, whereby the formation of the articles is effected simultaneously, each of the forming means being brought into coöperative relation to each of the separate molds in succession. In a glass forming machine, the combination of a blank mold and a finishing mold arranged one above the other, a transfer head, a plurality of neck molds carried by the head, and automatic means for imparting a step by step rotation to the head always in the same direction about a horizontal axis and thereby move each neck mold periodically from a position in register with the blank mold to a position in register with the finishing mold. In a glass forming machine, the combination of an inverted blank mold, a finishing mold therebeneath, a transfer head, a neck mold carried by the head, a reciprocating rack, a pinion in mesh therewith, and a one way driving connection between the pinion and the transfer head.

Glass-forming machine. L. D. SOUBIER. U. S. 1,626,703, May 3, 1927. In a glass forming machine, the combination of a rotary mold carriage, a group of molds thereon comprising blank molds arranged one in advance of the other in the direction of their travel and finishing molds arranged below the blank molds and one in advance of the other in their direction of travel, the faces of all the molds in the group, when closed being in the same plane, a transfer head between the blank molds and the finishing molds, neck molds on the head in register with the blank molds, means to open and close the molds, means to rotate the head and thereby carry the bare blanks supported in the neck molds downward, means to close the finishing molds around the blanks, and means to successively open the finishing molds as they reach the same discharging position.

Glass-forming apparatus. L. D. SOUBIER. U. S. 1,626,704, May 3, 1927. In a glass forming machine, the combination with a rotary mold carriage of mold bottoms arranged radially at different distances from the axis of the carriage, and automatic means for separately tilting the mold bottoms in succession. In a glass forming machine, the combination with means for simultaneously delivering a multiple of gobs of molten glass from a molten mass, of a support traveling in a closed path, a series of groups of molds thereon, each group comprising a multiple of blank molds adapted to receive the gobs of glass and form them into blanks, a complementary multiple of finishing molds, and means for transferring the blanks from the blank molds to the finishing molds and blowing the blanks to finish form therein.

Glass feeder. L. D. SOUBIER. U. S. 1,626,705, May 3, 1927. In a glass feeder, the combination of a container for molten glass having an outlet opening in the bottom thereof through which the glass issues, means for forming the issuing glass into mold charges comprising a regulator projecting over the opening and means for actuating the regulator periodically at regular intervals, a stirring device projecting into the glass at one side of the regulator, and means to cause the stirring device to move in a path surrounding the regulator.

Glass feeder. L. D. SOUBIER. U. S. 1,626,706, May 3, 1927. In a glass feeding device, the combination of a container for molten glass, having an outlet opening in the bottom thereof, a vertically reciprocating plunger in alinement with the opening, means providing a flowing stream of glass, an auxiliary container having an outlet opening above and in alinement with the first mentioned container, and means forming with the outlet opening of the auxiliary container an annular passageway through which the glass issues to the first mentioned container.

Apparatus for transferring glass articles. L. D. SOUBIER. U. S. 1,626,707, May 3, 1927. The combination of a carriage mounted for rotation about a stationary axis, a plurality of carriers mounted on the carriage and each comprising a plurality of individual compartments for receiving articles, the carriers being normally held in an article supporting position on the carriage and brought in succession to an article receiving position by the rotation of the carriage, automatic means for successively shifting the carriers relative to the carriage to an article discharging position, and automatic means for depositing articles in all the compartments of a carrier while the carrier is at the receiving position.

Means for forming charges of molten glass. RICHARD LA FRANCE. U. S. 1,626,737, May 3, 1927. The combination of a container for molten glass, having a plurality of outlet openings through which the glass issues simultaneously to form a plurality of charges, regulating means by which the issuance of glass through each outlet opening is independently controlled, whereby the relative sizes of the charges of glass issuing from the respective outlets may vary, and means below the outlets to sever the plurality of charges of glass.

Conveying apparatus. RICHARD LA FRANCE. U. S. 1,626,738, May 3, 1927. The combination of a machine for forming glass articles comprising a mold carriage, molds thereon operable to discharge articles during the travel of the molds, transfer mechanism comprising a carrier, automatic means to move the carrier and cause it to travel in register with the molds during the discharge of the articles and then move away from the mold carriage, and mechanism to actuate the carrier to discharge the articles therefrom.

Method and apparatus for fire-finishing glass articles. J. M. LENTS AND F. R. MILLER. U. S. 1,626,739, May 3, 1927. In fire finishing apparatus, the combination of a burner constructed to project an annular flame, means for bringing glass articles having circular open ends successively into operative relation to the burner and causing the annular flame to be projected against the open ends, and a pair of gripping jaws periodically operable to grip the articles while the flame is being projected against the open ends.

Apparatus for guiding and conveying hot glassware. M. J. OWENS. U. S. 1,626,747, May 3, 1927. The combination of a mold, a guide in position to receive and guide an article discharged from the mold, and manually operated means for inverting the guide to dislodge an article therefrom.

Bottle-transfer mechanism. M. J. OWENS. U. S. 1,626,748, May 3, 1927. The combination with a glass forming machine comprising a continuously rotating mold carriage, groups of molds thereon each constructed to deliver a group of articles at a discharging station in a plurality of successive steps while the mold group is passing the station, of article receiving apparatus comprising a plurality of stationary holders individual to the articles of the group and arranged to receive the articles as they are delivered from the machine, means for simultaneously releasing all the articles from the holders, and a multiple chute to receive the articles from the holders comprising means to keep the articles separated in their passage along the chute.

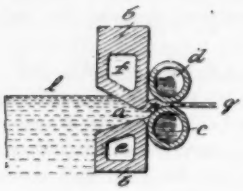
Method and apparatus for forming glassware. E. DANNER. U. S. 1,627,428, May 3, 1927. The method of forming sheet glass, consisting in causing molten glass to flow along a directing means and around opposite sides of a tip portion disposed at the discharge end of the means, the glass merging at the outer edge of the tip portion and flowing therefrom in single sheet form.

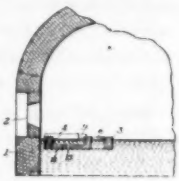
Molten-glass-feeding mechanism. E. T. FERNGREN. U. S. 1,628,238, May 10, 1927. In glass manufacturing, the method which consists in intermittently emitting a

voluminous freely vertically descending discharge of fluent glass from a flow spout, successively associating shearing means with the glass while in transit beyond the spout and cutting off quantities therefrom without previously affording under support for the quantities with the shearing means, receiving each cut-off quantity in a mold that is awaiting the same, and periodically in between such emitting of glass, and immediately after each cutting thereof effecting a limited discharging movement of glass in the spout and delivering heat to the glass that is in the spout.

Process and apparatus for feeding glass. W. J. MILLER. U. S. 1,628,324, May 10, 1927. In glass feeding mechanism, the combination of a receptacle for molten glass provided with a discharge orifice, means reciprocating within the receptacle for propelling the glass through the orifice, and a rotary stirring tool immersed in the glass within the receptacle, for the purpose described.

Process and apparatus for making sheet glass. L. BOUDIN. U. S. 1,628,353, May 10, 1927. The hereinbefore described process of feeding molten glass through a submerged issue opening of a glass container to a forming pass which comprises causing the glass to issue in a substantially horizontal direction in a highly heated condition through the issue opening under the head pressure of glass above the opening, and moving the glass issued from the opening to the forming pass at a rate which permits the creation under the head pressure of a meniscus on the glass outside of the opening.





Glass-gathering ring. L. J. HOUZE. U. S. 1,628,465, May 10, 1927. In a glass-gathering ring, the combination of a gathering opening, a melting hearth, a channel connecting the hearth with the gathering opening, and movable means for interrupting the flow of glass in the channel.

Heavy Clay Products

Some new ideas in clay working. H. R. STRAIGHT. *Jour. Amer. Ceram. Soc.*, **10** [5], 367–72 (1927).—The ideas which S. intends to try out on a plant scale are as follows: (1) roll crushing of the planer product, (2) use of a modernized soaking pit with pug mills, (3) heating pugged clay before molding, (4) air evacuation during pugging, (5) setting ware on kiln cars and running them through a humidity drier at a slow variable rate, (6) use of a wider tunnel kiln, especially for hollow ware, with special circulating features, and (7) mechanical handling of fired ware. Each idea is taken up and discussed in detail; all are along lines of eliminating manual effort, saving fuel, and increasing production per dollar invested.

Design of clay products plant employing tunnel kiln. H. R. STRAIGHT. *Fuels and Fur.*, **5** [5], 631–32 (1927).—S. gives an account of the improvements in a plant which he has designed and which will be built in the near future. Improvements in the way of installation of proper equipment and the coördination of the various departments were particularly desirable. S. describes the progress of the ware through the drier and the tunnel kiln explaining the principles that will be used in carrying out the drying and the firing. Less than one-fifth of the usual manual effort will be required, due to the improved lay-out and the handling equipment. It is expected that a more uniform ware will be made at a lower cost. A.E.R.W.

Mechanical introduction of barium to clay bodies. M. W. BLAIR. *Jour. Amer. Ceram. Soc.*, **10** [6], 464–66 (1927).—Several methods of introducing barium to clay

bodies are discussed. These include addition (1) in a wet dilute solution, (2) in a wet concentrated solution, (3) dry by sprinkling on to the raw clay in the car before grinding, (4) dry to the dry pan or crusher in proportion to the speed of the machine, (5) dry from a disk feeder applying the clay to the pug mill.

A comparison of clay plants. M. POHORZELECK. *Ber. deut. keram. Ges.*, **7** [4], 211–38 (1926).—A comparison of the methods of winning and purifying clay. F.P.H.

Freight rates do not limit quality. J. B. DILLION. *Brick Clay Rec.*, **70** [9], 705–707 (1927).—A description of the products of the Heinz Roofing Tile Co. The Zoar type roofing tile and Old English shingles are illustrated. F.P.H.

Hollow building tile under fire. ANON. *Brick Clay Rec.*, **70** [10], 769–71 (1927).—A report of the recently completed fire tests on hollow building tile carried out by the Hollow Building Tile Association at the Bureau of Standards. The initial part of the fire-resistance work consisted of tests of tile from 19 different plants, the tests being made by fire application on one side of piers 1 ft. wide and 6 ft. high. The results of this series of tests gave information which made possible the selection of a minimum number of plants for supplying tile of the various types and common designs for tests of large walls (11 x 16 feet). Auxiliary to the fire tests, compressive strength and absorption tests of all of the different kinds of tile were made, as also expansion and freezing tests, and chemical and microscopic examinations of typical kinds of tile and clays. A second series of fire tests was made to determine the influence of certain factors such as size of unit and effectiveness of plaster, and of certain changes which can be made in the manufacturing process. Tile with combustible filler (sawdust) to the amount of 5, 10 and 15% were tested. It was found that additions of combustible filler up to 15% to clays more especially to the dense firing clays, increases fire resistance. It was found that moderate fillets up to $\frac{1}{4}$- or $\frac{3}{8}$-inch radius are desirable, but that larger fillets are not beneficial. The tests showed that tile should be fired to a normal degree of maturity, but that hard-fired tile are more susceptible to fire damage. The third series consisted of fire-endurance tests and fire and water tests of large walls supplemented with a number of tests of walls 4 feet high in a small furnace. As indicated by the tests the ability of tile walls to carry load under fire exposure is governed by the kind of clay used for the tile and the design of the units. Tests were made on temperature transmission. F.P.H.

Research reveals important information. ANON. *Brick Clay Rec.*, **70** [10], 781 (1927).—Abstracts of 2 papers presented at the meeting of the Advisory Committee on Ceramics held at the Bureau of Standards, March 30. The 2 papers abstracted are: (1) "Drying Properties of Clays," by Wadleigh and (2) "The Study of the Extrusion Machines," by Grunwell. F.P.H.

Handling sewer pipe mechanically. ANON. *Brick Clay Rec.*, **70** [10], 873–75 (1927).—A description of the Ooms process, a German method of making sewer pipe. F.P.H.

Brick machines, old and modern. P. SCHMIDT. *Tonind. Ztg.*, **50,** 50th Anniv. No., pp. 26–27 (1926).—Since the power required for handling different clays varies it is difficult to design a machine which will do for all clays and this fact partly accounts for the slow progress being made in brick machines. In Germany the brick machines have been improved to a point where they make 5000 brick per day whereas in America machines are being used which make 2 to 4 times this amount. No effort is being made to improve brick machines in Germany at present because of the small demand for brick. It was customary in some of the earlier types of auger machines to have conical-shaped augers in conical-shaped cylinders. This design is faulty since the large portion of the auger may push 3 times as much clay forward as the smaller

portion of the same. Modern brick machines are equipped with 2 feeding rolls for forming thin wall ware which require a high pressure and a high strength. In the manufacture of roofing tile the old metal forms have been replaced with plaster molds. The revolver presses now being employed will produce 2 and 3 times as much pressure as the older types. New equipment is taking the place of men for cleaning molds. Conveyers are now being used to bring raw material to the presses and also to remove the freshly molded objects to the drier. H.G.S.

The drying practice. E. CRAMER. *Tonind. Ztg.*, **50,** 50th Anniv. No., p. 29, (1926).—The method of drying ceramic ware is governed by the ease with which the clay can be dried. The air in the drier should have very little circulation in the drier at the first portion of the same, but at the end there should be considerable circulation. If the clay is difficult to dry air having a high humidity should be introduced at the beginning of the drying. H.G.S.

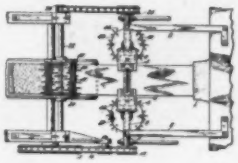
The clinker industry. G. MAUSZ. *Tonind. Ztg.*, **50,** 50th Anniv. No., pp. 33–34 (1926).—Ordinary brick are made from loam clay while the better class of ceramic products including clinker brick (brick with less than 2% absorption) are made from the more plastic brown coal clays. At the Klinker Werke der Ilse Bergbau-Aktiengesellschaft, Grube Ilse N.–1, they have 3 Mendheim gas-fired continuous chamber kilns fired with gas made from brown coal directly after it has been mined, *i.e.*, containing 58% H_2O. In a new plant built by this Company a 16-chamber Mendheim kiln was built, each chamber having a capacity of 10,000 4/4 brick. This kiln has been in operation since April, 1926, and is proving to be very satisfactory. The gas generators are 2.5 m in diameter and have a capacity of 18 tons of sieved brown coal per 24 hrs. It is a solid grate type of generator and it is claimed to save 25% fuel when compared with the open grate type. The draft used in these generators is about 850 cm. per hr. The drying is done above the kilns by means of heat radiated from them. The drying period is about 8 to 10 days and the drier consists of 26 chambers having a capacity of 6200 4/4 brick per chamber. A double ventilator requiring about 25 h.p. to operate the same is used. This drier takes care of all the brick for the continuous kiln and also for a 4-chamber periodic gas-fired kiln. H.G.S.

Standards association endorses brick sizes. ANON. *Can. Eng.*, **52** [14], 402 (1927); *Eng. Jour. Can.*, **10,** 235 (1927).—Under the auspices of the Canadian Engineering Standards Assn. a conference on standardization of brick sizes was held. The representatives at the conference adopted a formal resolution passed by the Canadian National Clay Products Assn. earlier in the year recommending standard sizes for common, rough-face, and smooth-face brick. The sizes adopted have already been recommended by the Division of Simplified Practice in the U. S. See also *Ceram. Abs.*, **6** [6], (1927). R.A.H.

Extrusion machine auger and die investigation. ANON. Bur. Stand., *Tech. News Bull.*, No. 120, p. 4 (1927).—An eastern Maryland brick clay in which 25½% water was used for tempering has been used in all recent studies. The workability of this material was found to be little affected by repeated extrusion through a brick die, but as expected the flow pressure increased as the moisture decreased due to the working of the clay. It was found that the unit output for single, double, or triple winged augers decreases as the length of the collective spacer between the tip of the auger and the mouth of the die or the length of the die increases. For this type of clay (medium plastic) the data collected shows that a single-winged auger, a 6-inch brick die of one degree taper, and a 6-inch collective spacer form the most efficient combination both as to quality of the column and power consumption. R.A.H.

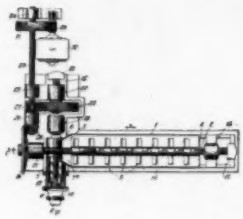
PATENTS

Brick machine. H. R. McCUNE. U. S. 1,626,619, May 3, 1927. An ornamenting attachment for brick machines, including supporting means, a rotatable picker device, means to mount the pickers for rotary movement independent of movement of the device, and means to positively rotate the device.

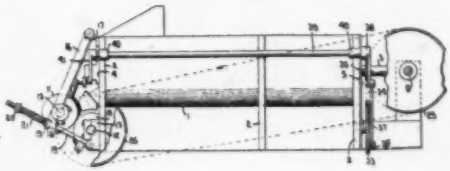


Apparatus for handling bricks. G. H. STOVER. U. S. 1,626,644, May 3, 1927. Apparatus for handling bricks comprising a platform to receive bricks in stacked relation, tracks for conducting the platform from place to place, hoisting mechanism including a substantially L-shaped frame one arm of which may be inserted beneath the platform, and means connected to the other arm of the frame for elevating the frame to raise the platform from or place it upon the tracks.

Clay tempering and expressing apparatus. W. L. HANLEY, JR. U. S. 1,626,675, May 3, 1927. In a machine of the character described, the combination of a horizontally disposed clay tempering cylinder, and a horizontally disposed expressing cylinder located adjacent to the discharge end of the tempering cylinder and substantially perpendicularly thereto, rotary tempering and feeding devices located in the tempering cylinder, and constructed to effect a feed of the material from the delivery end of the tempering cylinder to the discharge end thereof, the tempering cylinder being of such length as to reduce clay and water admitted to its outer end to proper plastic condition during its travel to the discharge end thereof, the tempering cylinder having a discharge aperture, the lower edge of which is substantially coincident with the bottom of the cylinder, communicating directly with a corresponding aperture in the side of the expressing cylinder, and located slightly above the bottom of the expressing cylinder, an expressing auger located in the expressing cylinder, and common driving means for the auger and for the clay tempering devices located closely adjacent to the intersection of the cylinders.



Brickmaking machinery. A. O. DUPUY. U. S. 1,627,079, May 3, 1927. The combination with a pugmill having a discharge opening at one end, of a pair of crusher rolls mounted adjacent the opening, a pivotally mounted spout adapted to direct the material discharged from the opening to the rolls and a reciprocating finger adapted to travel between the rolls and the spout, the finger being a point for suitably clamping the bolts against the side of the spout and beyond the ends of the rolls.



Refractories

Elasticity and transverse strength of sagger clays at elevated temperatures. ANON. Bur. Stand., *Tech. News Bull.*, No. 120, p. 4 (1927).—Seventeen sagger clays have been tested for moduli of elasticity and rupture (1) at room temperature, (2) at the temperature (ranging from 350 to 925°C) at which saggers made from these clays failed in an air quenching test, and (3) at 750°C. Determinations of moduli of elasticity at room temperature gave values ranging from 889,000 to 9,430,000 lbs./in.^{2} The majority

of clays were found to become more rigid at 750°C when compared with room temperature. The data obtained indicates an approximate direct relation to exist between transverse strength and elasticity and an inverse relation between porosity and elasticity. Because it is believed that modulus of elasticity, thermal expansion, and transverse strength are the most important factors in determining the resistance of a sagger to thermal shock, these 3 factors were combined in an empirical formula which gives a factor that indicates the resistance of a sagger to failure due to thermal shock. The values used in this formula must be obtained at some temperature higher than room temperature since values obtained at room temperature do not give the correct factor. R.A.H.

The refractory industry. M. SCHULTZ. *Tonind. Ztg.*, **50,** 50th Anniv. No., pp. 37–38 (1927).—The rapid growth of the refractory industry is due to the rapid growth of the steel industry since about 70% of the refractories are used by the iron industries. The dissemination of technical articles on refractories is done by the "Berichte des wissenschaftlichen Fachausschusses des Bunde deutscher Fabriken feuerfeste Erzeugnisse, Berlin." H.G.S.

The influence of grain size of flux and materials used to decrease the plasticity of clays on the cone deformation point of clays. HERMANN SALMANG. *Ber. deut. keram. Ges.*, **7** [2], 100–109 (1926).—The following mixtures were studied: (1) clay-quartz, (2) clay-feldspar, (3) clay-mica. A mixture of 75% kaolin and 25% quartz had a cone deformation point of 35 when the size of quartz was 1500μ and a deformation point of 31 when size the quartz grains was 2μ using a heating rate of 15°C per minute. The difference was not as large with a heating rate of 5°C per minute. In a mixture of 50% kaolin and 50% feldspar the cone deformation point was changed from 32 to 27 when the size of the feldspar was changed from 1500μ to 2μ using a heating rate of 15°C per minute. On a heating rate of 5 per minute there was practically no difference. The variation in size of the mica showed a difference of 2 points when the size was varied from 2 to 400μ. F.P.H.

The determination of the softening temperature of refractory material. OTTO BARTSCH. *Ber. deut. keram. Ges.*, **7** [3], 121–30 (1926).—A discussion of the various factors affecting the softening temperature of refractories under the load test. The position of the test specimen in the furnace is shown to affect the softening temperature. If the center of the specimen is not exactly in the hottest zone of the test furnace the softening temperature is shown to vary considerably. The Seger cone equivalent for a number of German refractory clays is given and varies from 28 to 35, while the softening temperature varies from 1325°C to 1410°C. F.P.H.

The expediency of establishing a testing laboratory for refractory materials in a metallurgical plant. The arrangement and problems of the testing laboratory. FRITZ ILLGEN. *Ber. deut. keram. Ges.*, **7** [4], 173–90 (1926).—The following subjects are discussed: (1) the need for a testing laboratory, (2) the arrangement and problems of the laboratory, (3) the tests required for each type of refractory used in the different metallurgical plants, (4) the apparatus required for the tests, (5) the interpretations of the results obtained with the different types of apparatus, (6) the organization for the testing laboratory, (7) the advisability of establishing a central testing laboratory. F.P.H.

A contribution to the improvement of saggers. JOS. DORFNER. *Ber. deut. keram. Ges.*, **7** [4], 211–38 (1926).—The following tests were carried out on a series of bond clays and sagger mixtures: (1) temperature at which softening begins, (2) temperature at which a test bar is deformed 2 mm, (3) time required for this deformation. The temperature at which softening begins with the bond clays varied from 1175 to 1300°C. The temperature at which the test bars of bond clay deformed 2 mm varied from $3\frac{1}{2}$ to

4 hours. The softening temperature of the sagger mixtures varied from 1300 to 1580°C. The temperature at which the test pieces of the sagger mixtures was deformed 2 mm varied from 1500 to 1600°C. The time required for this deformation varied from 3 to 5 hours. The effect of the distribution of grain size of grog on the stability of the sagger mixtures was studied. The following proportions of clay and grog were found best: 20–25% bond clay, 20–25% lean clay, 50–60% grog. A microscopic examination of the sagger bodies after one firing and after several firings was made and the solution of quartz noted. Numerous photomicrographs are given in the text. D. concludes that by the proper selection of bond clays, proper mixing of components, proper distribution of grain size of grog and by the proper proportioning of components that the life of saggers can be increased. F.P.H.

The alteration of silica brick in service in a Martin furnace. E. SIEURIN. *Ber. deut. keram. Ges.*, **7** [5], 241–48 (1926).—The practice in American and certain European plants in late years has been to fire silica brick until the specific gravity was about 2.32–2.35. In certain other European plants the practice has been to fire these brick until the specific gravity was 2.45. An opportunity was obtained to compare these 2 classes of silica brick in service in a basic Martin furnace. The following tests are carried out on these 2 classes of silica brick before and after service in the same furnace: (1) chemical analysis, (2) cone deformation point, (3) specific gravity, (4) porosity. The brick with a density of 2.35 showed less resistance than that one of a density of 2.45. From the results obtained, S. agrees with those opinions expressed in the "Memoirs of the Geological Survey" Vol. 16, Refractory Materials: Ganister and Silica Rock Sand for Open Hearth Steel Furnaces:Dolomite. For the steel furnace the relatively dense brick would appear to hold the field, but for many purposes where corrosion by slagging is no longer the main factor in durability it becomes possible to give fuller attention to the elimination of expansion; this is especially true of brick for coke ovens. Density and porosity are to a great extent mutually exclusive properties, between which a choice must be made, but without doubt a high density is the more important. On this account overfiring, which lowers the density, is undesirable. Quartz has the greater density than other forms of silica, and provided that the other properties are satisfactory, the best brick is to be expected from the use of as large a portion as possible of a ganister that does not undergo conversion during firing. F.P.H.

The changes in silica brick during its use in the Martin furnace. E. LUX. *Ber. deut. keram. Ges.*, **8** [1], 57–61 (1927).—A discussion of a paper on the same subject by E. Sieurin, *Ber. deut. keram. Ges.*, **7** [5], 241 (1926). F.P.H.

Investigation of refractory brick for coal-fired boiler installations. BRUNO SCHAPIRA. *Feuerungstech.*, **15** [11], 125–27; **15** [12], 137–39; **15** [13], 148–51 (1927).—An abstract of Technologic Paper, No. 279 of the U. S. Bureau of Standards. F.P.H.

Lamination, the foe of fire brick. C. B. STOWE. *Brick Clay Rec.*, **70** [10], 777–79 (1927).—S. claims it is impossible to overcome lamination in stiff-mud process. F.P.H.

Utility of refractories. ANON. *Brick Clay Rec.*, **70** [10], 792 (1927).—A chart prepared by the American Refractories Institute entitled "Utility of Refractories." The 2 main factors considered are: (1) conditions of service, (2) properties of refractories. Other factors considered are: (1) resistance to destruction, (2) strength, (3) confinement of heat. F.P.H.

The microscopic investigation of quartzites and silica brick containing lime. J. E. HIBSCH. *Feuerfest*, **2** [10], 93–95; **2** [12], 113–17 (1926).—The use of the binocular and mineralogical microscopes in determining the constituents and structure of quartzite and silica brick is discussed. The optical constants and transition temperatures of the

various forms of silica are given. Several photomicrographs of silica brick are given showing the various stages in the quartz-tridymite-cristobalite transformation.

F.P.H.

Directions for designing a gas-works oven. L. LITINSKY. *Feuerfest*, **3** [2], 17–19 (1927).—Directions are given for designing the chamber, generator, and recuperator of a gas-works oven. F.P.H.

The influence of molten glass on refractory materials. A. JAESCHKE. *Feuerfest*, **3** [2], 19–20 (1927).—A discussion of the action of soda-lime glass on refractories.

F.P.H.

The determinations of the fusibility of clay from its combined water content. H. TSCHISCHEWSLAY. *Feuerfest*, **3** [2], 20–22 (1927).—T. shows that as the chemically combined water content increases the fusion point of the clay increases. F.P.H.

The construction of a Siemens-Martin furnace. E. COTEL. *Feuerfest*, **3** [3], 37–39 (1927).—A description of the construction of a Siemens-Martin furnace with special reference to the refractories and mortar used in such furnaces. F.P.H.

The influence of the grain size of fluxes and lean materials upon the melting point of clays. ANON. *Continental Met. Chem. Eng.*, **1**, 87 (1926).—Hitherto melting points of clay have been considered in connection with chemical composition only, without due attention to physical properties, which are of greatest influence on behavior of clay. The 2 most important physical influences on melting point, grain size of admixtures, and duration of heating have been studied by H. Salmang. Zettlitz kaolin, quartz, feldspar, and mica were mixed in varying amounts and grain sizes, formed into Seger cone shape and heated to the melting point together with corresponding Seger cones. The varying grain sizes were produced by elutriation in following sizes: 2, 3, 8, 20, 40, 150, 400, 1500. The more rapid the speed of heating, the more important the influence of grain size. The melting temperature of Seger cones was found to be correct at a heating velocity of 5°C per minute. Since Seger cones are provided with fluxes of different grain sizes, they will begin to sag at different heating velocities and at different temperatures. The test cones used in the experiments which contained material of finest grain only sagged within an appreciably narrower temperature interval, providing the Seger cones, if used as temperature controlling medium will give more exact results if made up of materials of finest grain only. Experiments have shown that grain size and velocity of heating are of greatest influence on melting point.

TABLE I

A. Velocity of heating = 15°C/min.

Medium grain size	75 kaolin 25 quartz SC	50 kaolin 50 quartz SC	75 kaolin 25 feldspar SC	50 kaolin 50 feldspar SC	75 kaolin 50 mica SC	50 kaolin 50 mica SC	50 kaolin 25 feldspar 25 quartz
2.3	31–32	29–30	32–33	27	33	30	27–28
8	31–32	29–30	32–33	28	33	30	29
20	32–33	30–31	33	28–29	33–34	30	—
40	33	31–32	33	29	33–34	31	31
150	33	32	33	31	33–34	32	—
400	34–35	34–35	33–34	31–32	34	32	—
1500	35	35	33–34	32	—	—	—

B. Velocity of heating = 5°C/min.

Medium grain	75 kaolin 25 quartz SC	50 kaolin 50 quartz SC	75 kaolin 25 feldspar SC	50 kaolin 50 feldspar SC	75 kaolin 25 mica SC	50 kaolin 50 mica SC
2.3	32–33	31		28–29		
8	32–33	31		28–29		
20	33	31		29		
40	33	31–32	33	29	33–34	31
150	33	31–32		29–30		
400	33	32		29–30		
1500	33	32	—	—	—	—

In order to eliminate influence of grain size and to get comparable Seger cone melting points, the velocity of heating was reduced to 5° per min. Still larger reduction of velocity is advisable in the case of clays and other refractory materials containing large percentages of coarse grained quartz in order to correspond absolutely with actual conditions in industrial furnaces in which velocity of heating is usually much more gradual. The more rapid the speed of heating the more important the influence of grain size. O.P.R.O.

Dolomite. W. R. D. JONES. *Iron Coal Trades Rev.*, **114,** 563 (1927).—The manufacture of dolomite brick has been more or less a failure, but the use of dolomite for tamped linings is very extensive. Considerable success has resulted in the use of shrunk dolomite for converters and the beds of basic open-hearth steel furnaces, both for constructional and fettling purposes. The dolomite rock has to conform with rather exacting conditions as to the texture and silica content, if it is to be used as a basic refractory material. The silica present forms, with the basic materials, comparatively fusible silicates, *e.g.*, fosterite (Mg_2SiO_4), woolastonite ($CaSiO_3$). Before any dolomite rock can be a suitable source for "basic" it should conform to the following conditions: (1) its silica content should be less than 2%, (2) the chemical composition should be constant over areas sufficiently extensive to give a large supply of the material, (3) the proportion of magnesium carbonate should be as near as possible that of true dolomite, *i.e.* 45%, (4) it should be firm and compact and not easily weathered. O.P.R.O.

Bauxite in France. ANON. *Chem. and Ind.*, **46,** 323 (1927).—A bill has been put forward in the French Chamber with the object of reserving the national production of bauxite so that the ever-growing needs of the French aluminum industry may be filled. H.H.S.

Studies of pot solution. OTTO BARTSCH. *Glastech. Ber.*, **4** [7], 260–72 (1926); **4** [8], 286–97 (1926).—The method of testing consisted of melting the various raw materials and test batches in small crucibles and determining the loss in weight after all the melt had been removed from the crucible with dilute hydrochloric acid. The following separate phases were studied: (1) the attack on the pot by the individual ingredients of a glass batch; (2) the effect of temperature; (3) the effect of porosity; (4) the attack on the pot by borate melts; (5) the effect of the chemical composition of the melts; (6) the effect of the chemical composition of the pots; (7) the effect of the porosity of the pots; (8) the effect of the melting temperature on pot solution, (*a*) theoretical considerations of the effect of temperature on the kinetics of reaction, and (*b*) experimental determinations of the effects of melting temperatures on pot solution; (9) typical pot solution phenomena produced by disintegration of the melts; and (10) typical limited pot solution by higher oxide concentrations. Each of these separate studies is fully described and discussed. E.J.V.

The application of recuperators to open hearth furnaces. W. H. FITCH. *Fuels and Fur.*, **5** [5], 643–44 (1927).—F. describes a recuperator installed in combination with regenerators in equipment in which the temperatures are similar to the requirements of the open hearth. The recuperator tubes are made of Carborundum, treated to prevent oxidation and provided with "core busters" of fire clay. In application to an open-hearth furnace the limiting factors would be the nature, quantity, and temperature of the dust deposited in the tubes. F. shows that the dust would be below its plastic temperature and could be removed by means of soot blowers similar to those used in boiler practice. A.E.R.W.

The relation of the silica transformations to the behavior of refractories in use. E. STEINHOFF. *Gas u. Wasserfach*, **70,** 237–40 et seq. (1927).—A discussion. (*C. A.*)

Zirconium refractories. MARCEL SEILLAN. *Chaleur et industrie*, **8,** 84–86 (1927).—Description of Zr minerals and ores, of early work on Zr refractories, of the Karl and

LeCoultre process for the agglomeration of ZrO_2 (Fr. pat. 584,721, Nov. 27, 1924.—Agglomeration is obtained by maintaining the Zr ore for a sufficient length of time at about 1900°), and of the properties of Zr refractories. (*C. A.*)

The theory of glass pot production. O. KNAPP. *Keram. Rund.*, **34,** 72(1926).—The Bischof "refractoriness" of a clay was given by the relation b^2/ac, where a = % silica; b = % alumina; and c = % fluxes. The chemical behavior depended on the composition and grain size. Substances, like glass, containing free silica should only be allowed to come in contact with "acidic" refractory materials. The clay was "acidic" when $\beta < \alpha < \gamma$ where β, α, and γ were the molecular percentages, respectively, of the alumina, silica, and fluxes. The average surface area of 1 gm. of dry clay was given by the formula $3/2.6v$, where 2.6 was the density of the clay and v the average diameter of the grains. The greater the average diameter of the grains, the smaller the surface area and the greater the resistance. Mechanical behavior depended on the physical properties, which were influenced by working, drying, and firing. The clay could hold more water the smaller the grain size. Shrinkage on drying depended on grain size and on the water content. The greater the grain size, the smaller was the shrinkage. The rate of drying was proportional to the porosity. The greater the drying shrinkage the greater the crushing strength. It was necessary for the bind clay to have sufficient plasticity and binding power. (*Jour. Soc. Glass Tech.*)

Mixtures for glass pots and tank blocks. O. KNAPP. *Keram. Rund.*, **34,** 240(1926). —After reviewing the data in the tables, K. concluded: (1) specifications for mixings must include the chemical composition of the clays, and the composition must be considered; (2) the proportions of raw and fired clay must not be decided on according to a recipe but by experiment; (3) the addition of potsherds must be as great as possible; (4) when no special reasons indicate otherwise, a single kind of clay should be used, and (5) the grain size must always be specified. (*Jour. Soc. Glass Tech.*)

PATENTS

Method of producing fired ceramic blocks. P. G. WILLETTS. U. S. 1,626,260, April 26, 1927. The method of producing a fired ceramic block having substantially equal opposite faces, from material that tends to shrink unequally during firing, which method comprises placing the block upon a support of material which, during firing, will shrink at least as much as the block, and subjecting the block and the support to a temperature at which the block tends to shrink unequally.

Method of making refractory blocks. P. G. WILLETTS. U. S. 1,626,261, April 26, 1927. In the manufacture of refractory blocks which during firing, shrink unequally at top and bottom, the process of producing such a block having equal opposite faces that comprises making one of such faces smaller than the opposite face, and firing the block upon a substantially nonshrinking support with the smaller face down.

Method of treating alunite. T. A. MITCHELL. U. S. 1,628,174, May 10, 1927. The method of treating alunite comprising the steps of mixing raw crushed alunite with an alkaline earth metal compound capable of forming a sulphate by reaction therewith, the amount of the compound present being in excess of that which is the equivalent of the aluminium in the alunite for forming an alkaline earth metal aluminate, and calcining the mixture to form an aluminate having alkaline earth metal sulphate interspersed therethrough.

Method of molding silica. L. B. MILLER. U. S. 1,628,417, May 10, 1927. The method of producing a hollow silica article which consists in heating a charge of silica to plasticity in a mold, introducing a core member into the plastic charge, then cooling to cause the charge to solidify, in the mold with the member in place, the cooling occurring with sufficient rapidity after introduction of the core member to prevent adhesion of the charge and core member and finally removing the mold and core from the solidified charge.

Process of producing vitreous silica. L. B. MILLER. U. S. 1,628,468, May 10, 1927. The process of producing vitreous or fused quartz from crystal quartz which consists in heating the material to a temperature adjacent to but below about 1700°C, cooling the same to a temperature below 270°C, and finally fusing the material in a vacuum.

Refractory articles. ALUMINUM CO. OF AMERICA. Brit. 262,403, Nov. 2, 1926. Hollow globules of a fused refractory oxide low in silica, *e.g.*, alumina or a mixture of alumina with a small proportion of other refractory oxides, are molded under pressure with the addition of a small proportion of a suitable binder, preferably containing a relatively large proportion of the oxide forming the globules, *e.g.*, sodium or calcium aluminates. The product, after drying and firing, has a high thermal resistance and melting point with good mechanical strength at high temperatures. (*Brit. C. A.*)

Terra Cotta

An interesting color problem. H. SPURRIER. *Jour. Amer. Ceram. Soc.*, **10** [5], 330–33 (1927).—A terra cotta glaze that had not previously shown any color suddenly burned to a pink. The cause of the color was found to be chromium communicated by the kiln atmosphere. An exceedingly delicate test for chromium and an interesting use of complementary color effects were developed.

White Wares

The microstructure of earthenware. H. INSLEY. *Jour. Amer. Ceram. Soc.*, **10** [5], 317–26 (1927).—Nineteen samples of glazed earthenware bodies were examined with the petrographic microscope to study the development of mullite ($3Al_2O_3.2SiO_2$) within the body and at the glaze-body contact of the different samples. A correspondence of the development of mullite within the body and at the contact of glaze and body was observed and there seemed to be a relation between the firing temperature of the body and the size of mullite needles formed. Seventeen photomicrographs are shown.

Bureau of Standards investigation of feldspar—second progress report. R. F. GELLER. *Jour. Amer. Ceram. Soc.*, **10** [6], 411–34 (1927).—The history and purpose of the investigation are outlined and detailed reports are made on (1) the results of air elutriation and coöperative sieve and chemical analyses of the 19 feldspars being studied, (2) coöperative determinations of softening point, and (3) true specific gravity. The paper also includes a report on tests of mechanical strength, light transmission, porosity, volume shrinkage during firing, and thermal expansion of whiteware specimens in which the feldspars being studied were the only variable component.

Discussion on "The effect of calcined cyanite in porcelain bodies." L. NAVIAS AND S. J. MCDOWELL. *Jour. Amer. Ceram. Soc.*, **10** [5], 327–29 (1927).—N. questions the possibility of mullite development in a feldspar glass and presents observations in his work which seem to support the objection raised. M. views the matter from a thermochemical standpoint, and, using a diagram based on the existing data, shows the seeming possibility of mullite developing from feldspar. The entire question is more or less a matter of opinion due to the lack of comprehensive data thereon.

An outsider's view of the inside of the whiteware industry. C. C. TREISCHEL. *Ceram. Age*, **9** [4], 99–102 (1927).—T. gives in a condensed form some of the economic and technical problems confronting the various branches of the whiteware industry. To simplify the presentation the industry is divided into 4 main sections, 2 of which are subdivided into 2 sections each. *1. Dinnerware.*—The plants manufacturing china tableware for home and hotel use represent the largest capital investment of the 4 major groups. Dinnerware production for the past five years has averaged about 80% of capacity. Great possibilities for improvement from the technical standpoint

exist, such as the use of technical plant control systems. Examples are given. The position of the vitrified china manufacturer is not so difficult as that of the manufacturer of the so-called "semiporcelain." Foreign competition has practically forced the domestic vitrified product out of the field of dinnerware for household use, although the former is superior from the standpoint of toughness and resistance to rough handling. The rather soft glaze seems to be the chief objection to our present product. Great progress has been made in design and decoration. *2. Sanitary porcelain.*—At present the industry is experiencing the unpleasantness of a readjustment that can have no other result than the survival of the fittest. The chief reasons seem to be a market limited by building construction, a wholesale change from the pressing to the casting process, and the introduction of the tunnel kiln. To realize the economies of the tunnel kiln the plants must be run to capacity thus resulting in accumulations of stock during those periods when the markets fail to absorb. This eventually lowers the cost to the consumer and eliminates the inefficient plants. The control of the casting process and the development of single-fire body and glaze mixtures present interesting technical problems. The trend toward color in interior decoration may result in the use of large quantities of colored sanitary ware. *3. Floor and wall tile.*—Due to a steadily increasing market, overproduction is not current in the floor and wall tile industry. Foreign competition runs chiefly to vitrified and faience grades of wall tile. The industry is intelligently organized and conducted and the modern plants are models of efficiency. The crazing of glazes, the development of colored glazes and the manufacture of vitrified glazed wall tile present interesting problems. The production of vitrified colored bodies for floor tile, especially red and black is still a problem. *4. Electrical porcelain.*—Low voltage porcelains are divided into "standard" and "specialty" groups, and are limited to service below 2500 volts. The manufacture of "dry-process" porcelain is carried on in much the same way as it was 25 years ago. The industry is in the hands of a large number of small concerns and amalgamation does not appear to be imminent. Production has averaged about 70% of capacity for the past 5 years, indicating that profits are small. Cold-molded material is an important competitor, mostly on a price basis. Mixtures suitable for mechanical presses are in great need and amalgamations are needed. High voltage porcelain is made by the plastic method or by casting, the former being used for the bulk of the output. The majority of the companies are large and have fairly modern plants, the industry being sound and stable from this viewpoint. Problems of great technical interest abound as no flint–clay–feldspar mixtures yet developed have the 3 major requirements in the highest degree. New raw materials seem to be necessary, although control of the present bodies is a difficult problem. The materials should be adapted to making pieces varying greatly in size. A.E.R.W.

Methods of purifying materials containing kaolin. M. POHORZELECK. *Ber. deut. keram. Ges.*, **7** [4], 190–94 (1926).—The following methods are described for purifying raw clay: (1) natural elutriation, (2) elutriation by the use of flowing water, (3) surface elutriation, (4) elutriation without the use of flowing water to which belong (*a*) the purification of clay by the use of peptizing agents, (*b*) the use of electrolytes, (*c*) the purification and dewatering of clay by the use of method of electroösmosis. F.P.H.

The mechanical testing of table ware. R. RIEKE AND LISELOTTE MAUVE. *Ber. deut. keram. Ges.*, **7** [5], 248–72 (1926).—R. and M. discuss previous results obtained in testing the impact of table ware. The type of apparatus used in this investigation is similar to that used by Sortwell, *Jour. Amer. Ceram. Soc.*, **5**, 276–88 (1922), **6**, 349–55 (1923). Porcelain manufactured by 13 companies was tested. The impact strength was determined on the rim and base of the ware. The following results are averages for the impact strength on the rim of the plates that were tested.

Thickness of rim of plates		Strength of rim in cm kg	
2–3 mm	5–6 mm	.5–2 cm kg	2.0–3.0 cm kg
3–4 "	6–7 "	1.0–2.0 " "	2.0–4.0 " "
4–5 "		1.5–2.0 " "	

Thickness of base of plates		Strength of base cm kg	
3–4 mm	5–6 mm	over 1.5 cm kg	over 3 cm kg
4–5 "	6–7 "	" 2 " "	" 3.5 " "

The impact strength of German and American table ware is compared. F.P.H.

New investigations on the heat expansion and annealing temperature of glazes with special reference to the fitting of glazes to bodies. W. STEGER. *Ber. deut. keram. Ges.*, **8** [1], 24–43 (1927).—The expansion of a body can be varied by : (1) varying the type of clay, (2) raising or lowering the firing temperature, (3) variation in the proportion of feldspar, flint, and clay, (4) variation in grain size of quartz. The significance of the annealing temperature is discussed. The coefficient of expansion was determined on rods 1.8mm in diameter and 60mm in length by the uses of the microscope. The heating rate was 3°C per minute. Each glass rod was measured twice. The rods were heated to the critical temperature and cooled slowly and the second expansion determination was carried out on the rod free of strain. The following types of glazes were investigated: (1) one simple lead silicate glaze, (2) two complex lead glazes, (3) ten whiteware glazes for cones 09*a* to 01*a*, (4) seven whiteware glazes for cones 1*a* to 6*a*, (5) two soft porcelain glazes, (6) one hard porcelain glaze. The batch compositions of these glazes are given. A table showing the following temperatures for the various glazes is given: (1) beginning of release of strain in the glaze, (2) beginning and ending of critical zone, (3) beginning of softening. The results of Gehlhoff and Thomas on the annealing temperatures of glasses are reviewed and are as follows: (1) the alkalis greatly reduced the annealing temperature, sodium reduces it greater than potassium, (2) the annealing temperature is raised considerably by CaO; it is raised a small amount by BaO; it is depressed by PbO and raised by ZnO, (3) Al_2O_3 greatly increases the annealing temperature. With B_2O_3 the annealing temperature passes through a maximum at 20% B_2O_3. There is no linear relation between annealing temperature and chemical composition. A low annealing temperature for glazes is an advantage as the temperature interval between the point at which the glaze becomes nonplastic and the room temperature is small. The effect of varying the composition of bodies on the expansion curve is studied. The effect of temperature of firing of the body on the expansion curve for the body is studied. The higher the firing temperature the steeper the expansion curve. This is evidently due to the effect of cristobalite. The effect of the size of grain of quartz on the expansion curve is studied. The smaller the grain size of quartz in the body is, the steeper the expansion curve is, the composition and firing temperature being the same. F.P.H.

Physical properties of porcelain. ANON. *Ceram. Ind.*, **8** [5], 543 (1927).—A progress report of work of the Bureau of Standards on physical properties of porcelain. This report deals with the effect of time of firing on the coefficient of expansion and amount of chemical reaction between the quartz, feldspar, and clay of porcelain bodies. All the bodies were fired to cone 12 but the time required to bring cone 12 down varied from 16 to 40 hrs. The data indicate that: (1) relatively large quantities of quartz remain undissolved after the 16-hour firing, (2) the 30-hour firing has materially reduced the free-quartz content, (3) the 40-hour firing has practically eliminated the free-quartz content since the rate of expansion is practically the same from 560 to 580°C, (4) the firing to a certain cone is not a proper measure to the reactions which have taken place in the body since all these specimens were fired to cone 12 but as previously stated in varying lengths of time. F.P.H.

The stoneware industry. F. SINGER. *Tonind. Ztg.*, **50,** 50th Anniv. No., pp. 34–36 (1926).—The characteristic properties of stoneware are high resistance to acids, great hardness, low absorption, and a smooth resistant salt glaze. Some stoneware pipe were dug up in Berlin in 1920 which had been laid in 1875 and they were still sound after 45 years service. The sewer pipe industry represents the largest portion of the stoneware industry. Stoneware is also used for household utensils such as crocks, jars, plates, cups, and also for troughs, building and paving brick, for chemical stoneware, and high tension insulators. The following properties of chemical stoneware should be improved as much as possible, (1) strength, (2) heat conduction, (3) low coefficient of expansion, (4) low absorption, and (5) resistance to chemicals, especially bases. H.G.S.

The growth of the floor tile industry. O. KAUFFMANN. *Tonind. Ztg.*, **50,** 50th Anniv. No., pp. 36–37 (1926).—During the past 50 years floor tile of natural stone has almost entirely been replaced by artificial tile. Next to clinker and cement tile, stoneware or clay tile are used where greater durability is desired. The growth of the clay tile industry is largely dependent upon the use of blast furnace slag as a non-plastic ingredient in this body. Clay tile are, therefore, made in the Saar district since large amounts of slag are available here. Although clay tile are used to a limited extent because of the small color range with which these can be made they are still important for certain industries, but are gradually being replaced with stoneware tile. Of late colored tile have come into demand, and stoneware tile can be made into a larger variety of colors than the clay tile. In the preparation of the mixture for the stoneware tile it was formerly customary to grind the feldspar and sand wet and add the wet mixture to the dry powdered clay. By doing this a large excess of water is introduced into the batch and it must be dried to proper consistency. Now the feldspar and sand are ground fine dry as well as the clay and the proper amount of tempering water added. According to the German patent of E. Tuschhoff, the powder separated with an air separator is mixed with water in a wet pan whereby the mass is crushed into coarse grains in which condition it can be pressed easier. Big improvements have been made in presses and some producing a hydraulic pressure of 250 atmospheres are now being used. Tile pressed with 5% water are dried either during the watersmoking period or in driers before entering the kiln. More efficient methods are used in firing since instead of periodic kilns, coupled kilns, gas-fired continuous chamber kilns, and tunnel kilns are now being used. The chamber type of kiln has the advantage over the tunnel type in that ware can be fired to different temperatures in different compartments whereas ware in a tunnel kiln can only be fired to one temperature. H.G.S.

Leadless glaze. ANON. *Chem. and Ind.*, **46,** 297 (1927).—The Home Secretary stated in Parliament that the number of British potteries with leadless glaze certificates is 193, and that the number of potteries with low-solubility glaze certificates is 171, making a total of 364. The information given also included results of analyses. H.H.S.

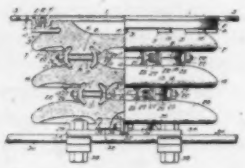
British tariff on translucent pottery. *Chem. and Ind.*, **46,** 341 (1927).—The Committee appointed under the Safeguarding of Industries Act to enquire into the English pottery industry, reported that nothing in the nature of "ring" prices exists in the industry, that present unemployment is due to the importation of foreign china, and that though some economies could be effected by coöperative working, the industry is carried on with reasonable efficiency and economy. The Committee recommended that a duty of 28 shillings per cwt. net weight be imposed on imported tableware of translucent pottery, for a period not exceeding 5 years. This duty has been imposed under the new budget. H.H.S.

BOOK

Deaths from lead poisoning. F. L. HOFFMAN. Dept. of Labor, *Bull.*, No. 426, 1927. Price 10c. H.H.S.

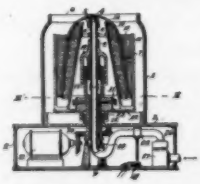
PATENTS

Insulator. W. T. GODDARD. U. S. 1,625,601, April 19, 1927. Means for securing together a plurality of superposed insulator sections, comprising radially extending bolt members recessed into the contacting faces of the sections and having angularly disposed fingers at their inner ends anchored within the sections, retaining elements carried by the bolts anchored within the outer peripheries of the sections, and nuts on the outer ends of the bolts engaging the retaining elements. In a high tension insulator, a metallic supporting section provided with an annular hub portion having a series of openings in the web of the hub, a disk-shaped section of insulating material provided with a series of radial openings engaging the supporting section within the annulus of the hub portion, and angular clamping members secured to the metallic member through the openings therein and having portions engaging within the openings in the insulating section to secure such sections together.



Tile-coating machine and process. L. S. JONES, G. W. FISHER, AND C. G. HENRIKSON. U. S. 1,627,096, May 3, 1927. A combination machine for treating tile of heterogeneous form comprising a series of parallel wires providing a traveling belt, bands of greater cross section than the wires at one side of the belt extending parallel to the wires, a chamber through which the belt travels, means for producing within the chamber a spray of glazing compound, doors in the chamber adjacent the bands, and pulleys at opposite sides of the chamber for guiding the elements of the belt in spaced relation to each other, substantially as set forth. In a machine adapted to treat tiles of irregular shape, a conveyer, a fixed arm above the conveyer, a finger secured to the arm for lateral, vertical and pivotal adjustment relatively thereto, and a nozzle pivotally supported on the arm, the nozzle being adjustable lengthwise of the arm, substantially as set forth.

Apparatus for cleaning potteries and the like. A. PARODI. U. S. 1,627,112, May 3, 1927. An apparatus of the character described including a casing embodying a lower closed chamber and an upper open chamber, a tubular shaft mounted vertically in the 2 chambers, a brush support carried with the shaft and positioned in the upper chamber, means in the lower chamber for rotating the shaft, valved liquid supply means located in the lower chamber, a pipe including a vertical portion slidably mounted through the shaft and projected into into the upper part of the upper chamber and having a horizontal portion continuing from the vertical portion and arranged through the lower chamber and a vertical lower portion continuing from the horizontal portion and forming part of the valve supply means, resilient means for holding the pipe in an elevated and closed position, the pipe being adapted to move downwardly upon the insertion of an object to be cleaned to actuate the valve supply means to allow liquid to pass through the pipe and to be directed against the inserted object, means for controlling the rotation of the shaft, and means carried with the horizontal portion of the pipe and coacting with the controlling means for rotating the shaft simultaneously with the depression of the pipe so that the brush support will be rotated while the liquid is being directed against the inserted object.



Process for making and molding hard porcelain. A. M. McINTOSH. U. S. 1,627,245, May 3, 1927. A process for forming porcelain ware comprising the subjection of ordinary finished porcelain to heat until plastic and then simultaneously subjecting the plastic material to pressure and molding it.

Insulator. W. T. GODDARD. U. S. 1,628,241, May 10, 1927. In a high tension insulator, a plurality of units arranged in superposed relation and having contacting faces formed with mating recesses, securing bolts arranged in circular series and embedded within the units with their threaded ends projecting into the recesses, and nut members upon the ends of the bolts and located within the mating recesses. In a high tension insulator, a plurality of sections of insulating material of disk form, nuts secured to the sections, and turnbuckle means for engaging the nuts to secure the sections together.

Molding with binders of the glyptal class. C. F. PETERSON. Brit. 250,942, April 14, 1925. Mica sheets for forming commutator cones or other articles are united by use of a solution of glyptal in acetone and by the action of heat and pressure. (*C. A.*)

Equipment and Apparatus

A convenient platinum-wound resistance furnace. EDWARD ORTON, JR. AND J. F. KREHBIEL. *Jour. Amer. Ceram. Soc.*, **10** [5], 373–87 (1927).—The problem was to produce a furnace with effective hot chamber less than 3 inches in diameter, by 4 or 5 inches in length. The temperature had to be uniform throughout this chamber, the control accurate, the atmosphere clean and oxidizing and able to melt cone 20. Details of construction of the furnace are given including the principal platinum resistor, the two end coils, Chromel booster coil, shell, refractories, insulators, etc., with detailed drawings and photographs. The log and graphs showing the behavior of the furnace in a cone 20 firing (1533°C) at a rate of temperature increase of about 33°C per hour are given. The cost of the furnace, the controlling apparatus, and the temperature measuring equipment, are given in detail. The furnace meets the requirements successfully, as to performance. Its practical value will depend on the life of the platinum resistor which cannot be foretold. In the 31 firings so far completed no changes have been observed in the electric performance or apparent condition of the furnace. Its performance at the end of the first year's operation will be given in a subsequent paper.

A new high temperature furnace controller. F. H. NORTON. *Jour. Amer. Ceram. Soc.*, **10** [6], 438–42 (1927).—The need for accurate control of an oil-fired furnace operated at a temperature above the range of platinum thermocouples led to the development of a new type of controller. Disadvantages of ordinary types of controllers are discussed. The mounting of the radiation pyrometer used is described. Full details of the construction and operating principles of the controller are given. Results obtained are far better than with most careful hand control.

The Holborn and Kurlbaum disappearing filament pyrometer. H. MIETHING. *Ceram. Age*, **9** [4], 112–14 (1927).—M. describes the principle of operation, construction, and use of a disappearing filament-type pyrometer. New developments are the micropyrometer, used for the measurement of the temperature of small bodies, and a pyrometer with a tele-objective, which is used in measuring the temperature of a furnace through a small aperture in the wall. A.E.R.W.

Highly efficient continuous electrode furnace. MARCEL ARROUET. *Fuels and Fur.*, **5** [5], 606 (1927).—A. gives a description of a 10,000 kw., single-phase furnace, provided with a new type of continuous electrode, called a "Miguet Electrode," that has recently been developed in France. The current is lead to a single electrode through a number of separate circuits arranged symmetrically around the furnace. A power factor of 95% can be secured with total currents as high as 240,000 amp. The electrode

is built by piecing together prebaked carbon segments. Arcing and reduction takes place only around the edge of the electrode. A 5000 kw. unit in operation in France has, during 1926, given an average production of 1 metric ton of carbide of calcium for 3100 kw. hr. A.E.R.W.

The spraying method of applying japan. W. J. MISKELLA. *Fuels and Fur.*, **5** [5], 623–26(1927).—M. describes the development of the present type of spray-gun from the original, cup-type spray-gun. A description is also given of the present type of pressure spray-gun and the accessory equipment such as air transformers, draining devices, and pressure containers. A.E.R.W.

Rubber as lining for grinding mills. B. W. ROGERS. *Ind. Eng. Chem.*, **19** [1], 139–40(1927).—Rubber linings are shown to aid the performance as well as the maintenance of grinding mills. The results of research to determine reasons for difference in performance between metal and rubber lining when operating under parallel conditions are discussed. A table of critical speeds for various sizes of mills and loads is given. See also B. W. Rogers and H. E. Fritz, "Rubber, an effective material to resist corrosion and adhesion," *Bull. Amer. Ceram. Soc.*, **5** [12], 467–72(1927). R.J.P.

An improved elutriation apparatus for use in plant control work. H. HARKORT. *Ber. deut. keram. Ges.*, **8** [1], 6–24(1927).—The principal part of the elutriation apparatus consists of 2 funnels, one large funnel and one small funnel with a long stem. The suspension is poured into the small funnel and flows into the large funnel and the smaller particles pass into the overflow. The velocity of the suspending medium is controlled by means of nozzles of various sizes fitted to the stem of the small funnel. The apparatus and method of procedure are fully described. Ammonia is used as the deflocculating agent. F.P.H.

Air separation methods used in fine grinding of rock products. EDMUND SHAW. *Rock Prod.*, **30** [9], 57–58(1927).—This is the 2nd of a series of articles on this subject. This article describes the application of air and centrifugal force and design of machines used in this process. F.P.H.

Graduation of machine-broken stone. W. T. W. MILLER. *Rock Prod.*, **30** [8], 62–63(1927). A study of the various sizes produced in jaw, disk, and roll crushers. F.P.H.

New dust-collecting installation at the Ford Motor Co. cement plant. ANON. *Rock Prod.*, **30** [8], 68–70(1927). F.P.H.

PATENTS

Dry-pan crusher. J. S. FOWLER. U. S. 1,625,887, April 26, 1927. In a dry pan crusher, a pan comprising a frame; an annular screen plate adapted to rest upon the frame, the screen plate being divided into a plurality of sections; depending marginal flanges at the edges of and integral with the sections; lugs formed with and longer than the width of the flanges, the lugs having slots therein; and bolts passing through the slotted lugs for separately connecting together the sections and adapting them for relative vertical adjustment.

Mold for casting clay blocks and the like and method of molding. J. M. LAMBIE AND D. W. ROSS. U. S. 1,625,947, April 26, 1927. A mold side comprising an open-work relatively rigid frame, provided intermediate its edges with a molding surface of porous plaster-like material.

Tubular pyrometer sheaths of sheet chromium steel. W. C. JOHNSON. Brit. 251,750, April 4, 1925.

Kilns, Furnaces, Fuels, and Combustion

Comparison of the expenses for operating three different types of kilns. O. KAUFFMANN. *Jour. Amer. Ceram. Soc.*, **10** [6], 467–68(1927).—A comparison made of a system

of 6 round kilns, a 16 chamber Mendheim gas kiln, and a tunnel car kiln system Saarau shows the tunnel car kiln to have the best figures concerning amount of fuel and time of firing, but less favorable with regard to wages and amount of broken saggers. There is also a difference in the quality of the tile.

Dressler tunnel kilns at the C. Pardee works, Perth Amboy. ANON. *Ceram. Age*, **9** [4], 109–110 (1927).—A description is given of a direct-fire biscuit kiln and a muffle glost kiln, each with a capacity of 9,000 sq. ft. of tile in 24 hrs. The biscuit kiln is unique in that, although it is direct-fired, the air for combustion is highly preheated, the kiln being entirely recuperative in its action. A very accurate control of the entrance-end temperatures is secured. A hot air fan is used in the indirect heating of air in the side-walls and above the crown for drying and plant-heating purposes. The glost kiln fires to a temperature of cone 03. Photographs of cones are used in indicating the great uniformity of firing that is secured. The producer gas used in firing is made in producers equipped with automatic coal feed and automatic fuel bed agitation, anthracite coal being used. A.E.R.W.

Automatic temperature control at plant of the Mount Clemens Pottery Co. ANON. *Ceram. Age*, **9** [4], 111 (1927).—A description is given of the latest type of Holcroft kiln, employing many modern devices that are new in ceramic operation. The automatic devices which are used to eliminate the personal element are described and illustrated by means of a photograph. A.E.R.W.

Effect of height of stack on furnace operation. W. H. MAWHINNEY. *Fuels and Fur.*, **5** [5], 579–81 (1927).—M. describes experiments and calculations which afford a comparison of the rate of variation of furnace pressure with variation in fuel consumption for an oil-fired, batch-type, rolling mill furnace with and without a stack. The following conclusions are drawn: (1) furnace pressure varies rapidly with fuel consumption, the proportionate increase being faster for increases in fuel consumption over normal than for decreases from normal and (2) for a given percentage change in fuel consumption, the change in furnace pressure is much greater for a furnace equipped with a stack than for one without a stack. M. points out the usefulness of practical automatic pressure control and of a decrease in stack height where other considerations do not forbid such a procedure. A.E.R.W.

Heat requirements of kilns in firing of clay. A. E. MACGEE. *Fuels and Fur.*, **5** [4], 493–96 (1927).—Abstract of paper presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Detroit, Mich., February, 1927. This paper will be published in an early issue of the *Journal of the American Ceramic Society*. A.E.R.W.

The specific heat and heat tone of clays, etc. WILLI M. COHN. *Ber. deut. keram. Ges.*, **7** [3], 148–55 (1926).—A criticism of an article by A. E. MacGee on the "Heat Required to Fire Ceramic Bodies," published in *Jour. Amer. Ceram. Soc.*, **9**, 206–47 (1926). A comparison of the values obtained by Cohn and MacGee is given. F.P.H.

The heat required to fire ceramic bodies. A. E. MACGEE. *Ber. deut. keram. Ges.*, **7** [3], 146–48 (1926).—Abstract of an article published in *Jour. Amer. Ceram. Soc.*, **9**, 206–47 (1926). F.P.H.

Making the pyrometer save money. H. C. KENYON. *Brick Clay Rec.*, **70** [9], 710–13 (1927).—K. tells how he cut firing time and fuel consumption and increased quality by the use of pyrometers. F.P.H.

Thermal calculations involved in designing a kiln for firing brick. K. F. OLENEW. *Feuerfest*, **3** [1], 2–5 (1927).—An example is given showing the methods involved in designing kilns, fireboxes and flues with the aid of the hydraulic theory of kiln design by Grum Grjimajlo. F.P.H.

The influence of preheated air on the combustion process. WILHELM GUMZ. *Feuerungstech.*, **15** [12], 133–37 (1927). F.P.H.

Theory of material conversion in combustion processes. M. WIERZ. *Feuerungstech.*, **15** [3], 27–30(1926). F.P.H.

Mechanical stokers for gas producers. RUDOLF MOLLER. *Feuerungstech.*, **15** [11], 123–25(1927).—The different types of mechanical stokers for gas producers are described and illustrated. F.P.H.

Luminous and nonluminous flames in industrial gas furnaces. KARL HUFFELMANN, *Feuerungstech.*, **15** [13], 145–46(1927). F.P.H.

Pure gases in glass plant operation. FRITZ GROSS. *Glastech. Ber.*, **4** [12], 449–58 (1927).—By pure gas is meant any gaseous fuel which may have been purified by any of a number of means. Its use in the glass plant is discussed in a general way. Details of regulation, superintendence, and distribution, the use of purified gas for melting furnaces and for the auxiliary furnaces and leers in the glass industry are taken up. E.J.V.

The relative ignition temperature of solid fuels. KENJI NAKAMURA AND AKIRA SHIMOMURA. *Mem. Coll. Sci. Kyoto Imp. Univ.*, A., **10**, 89–94(1926).—Air is drawn at a constant rate through a coal sample in a tube which is being heated externally by a sand bath; the relative ignition temperature is that at which the temperature of the coal "catches up" with that of the sand due to its increased rate of self-heating. Data are given for 18 oriental coals ranging from lignites to anthracite. Confirming previous results, in general the higher the O content the lower the relative ignition temperature. It is also indicated that low ignition temperatures are associated with high volatile matter and low ash, other conditions being constant. (*C. A.*)

BOOK

Heat economy in the ceramic industry. WALTER STEGER. 147 pages. Published by Th. Steinkopff, Dresden (1927). Bound in linen R M 9.5. The following subjects are treated: (1) the action of drying and firing on ceramic products, (2) alteration of ceramic bodies by drying and firing, (3) the physical fundamentals of drying, (4) arrangements for drying ceramic products and methods of operation, (5) drying in free air, (6) drying with artificial heat, (7) heat economy in drying operations, (8) physical and chemical fundamentals of firing, (9) kilns for firing ceramic products and methods of operating them, (10) periodic and continuous kilns, (11) heat economy in kiln operation, (12) arrangements and precautions to take in increasing the efficiency of kilns, (13) measuring instruments for supervising the drying and firing of ware, (14) temperature measurements, (15) measurements of pressure and draft of furnace gases, (16) analysis of gases and determination of humidity, (17) example of a heat balance, (18) plan for conducting an investigation of a round kiln, (19) example of a heat balance taken from practice, (20) data for practical use. F.P.H.

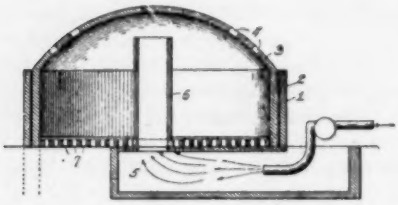
PATENTS

Brick-kiln construction. W. W. DICKINSON, JR. U. S. 1,627,598, May 10, 1927. A plurality of adjacent units made up of brick placed for firing, having a division wall initially of unfired brick, between each 2 thereof, the wall being of less height than the units, thereby providing initially a passage-way above the wall for gases of combustion between the units, and as firing and shrinkage of the wall progresses, providing additional direct passageways through the wall.

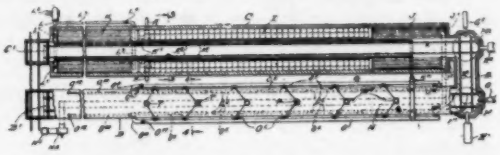
Combined brick kiln and drier. N. U. LUDWIG. U. S. 1,627,979, May 10, 1927. In a combined kiln and drier, a tunnel having longitudinally extending grooves in its side walls and longitudinally extending channels therebelow, cars adapted to travel in the tunnel, the cars having edge flanges fitted in the grooves to produce a stepped joint between the firing zone and the zone occupied by the wheels of the cars, lining plates in the channels, each of the lining plates having an upper depending

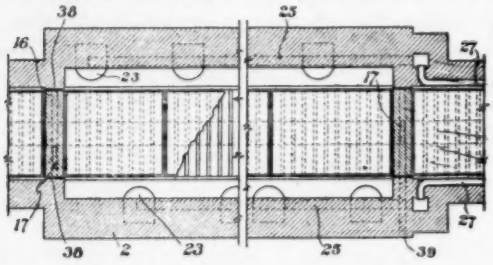
flange at the edge of the channel and terminating above the lower edge of the channel, troughs suspended from the cars throughout the lengths of the cars on each side thereof under the flanges and in such relation thereto that the flanges extend through the troughs, and a sealing agent in each trough into which the flanges project.

Single-fire-box kiln. W. E. WILSON AND H. G. LYKKEN. U. S. 1,627,720, May 10, 1927. In a kiln having a roof and a floor, a single fire box beneath the floor, the floor having an aperture connecting the fire box with the interior of the kiln and a plurality of apertures surrounding the first named aperture and communicating with the interior of the kiln, a plurality of passageways beneath the floor of the kiln with which the apertures in the floor communicate, and a common duct communicating with all of the passageways and connected with an exhaust duct so that the waste products of combusion may be withdrawn through the floor of the kiln.



Continuous kiln and drier. C. DRESSLER. U. S. 1,627,841, May 10, 1927. Brick drying and heating apparatus comprising in combination, a fire heated tunnel kiln in which the brick are fired, and a drying chamber in which the brick are dried, means for utilizing products of combustion from the tunnel kiln in heating the drying chamber, means for cooling the brick and brick transporting means in the tunnel kiln by the use of air thereby heated and means for injecting the air thus heated into the drying chamber at intervals along the major portion of the length of the latter to supply heat thereto and to serve as a vehicle for carrying moisture away from the brick and out of the chamber.





Method and apparatus for firing clayware. W. D. RICHARDSON. U. S. 1,628,273, May 10, 1927. The method of firing clay ware in tunnel kilns which comprises sealing one portion of the kiln from another and passing gases through a portion of the seal. In combination with a tunnel kiln of means on the conveying units for sealing the passage of gases above the ware and means for controlling the passage of gases through successive conveying units.

Geology

New source of borax found in California. ANON. *Chem. Met. Eng.*, **34**, 264 (1927). —The Pacific Coast Borax Co. has begun mining operations on its holdings near Mojave, Calif. The deposit contains a new mineral, a hydrate of sodium borate containing 4 molecules of water. It has been named "Rasorite." The new mine will eventually have a productive capacity equal to the entire world's consumption of borax.

M.E.M.

Rock products industry in South Dakota: andalusite, bentonite, feldspar, and gypsum. FRANCES J. LINCOLN. *Rock Prod.*, **30** [9], 53–56(1927).—The occurrence and mining of these minerals are described. Analyses of bentonites, feldspars, and gypsums found in this section are given. F.P.H.

The economic geology of the limestones of Illinois. J. E. LAMAR. *Rock Prod.*, **30** [8], 56–59(1927). F.P.H.

Fluorspar, its mining and markets. E. L. BROKENSHIRE. *Glass Ind.*, **8** [5],120–21 (1927).—The chemical and physical properties of fluorspar, CaF_2, are discussed. Distribution of deposits in the U. S. and data on domestic production and importation of fluorspar are taken up. The steel industry uses 80 to 85% of the total American consumption in the manufacture of open-hearth steel, from 7 to 10% is used in the manufacturing of ceramic products such as enameled and sanitary ware and opalescent glass, and about 5% is used in foundry cupola practice. The highest grade fluorspar, 98% CaF_2 and maximum 1% SiO_2, is used in manufacturing hydrofluoric acid. The mining, crushing, and concentration of fluorspar is described. E.J.V.

Canadian ceramic materials. ANON. *Chem. and Ind.*, **46,** 375–86–91, 395(1927). —The April 29 issue of above *J.* is a special Canadian number with numerous illustrations, and many of the articles are of ceramic interest. Lithia, used in the glass industry in order to reduce viscosity, especially in the manufacture of lamp bulbs and special kinds of glass, occurs in lepidolite and spodumene, large deposits of which have been found in Manitoba. Cobalt oxide comes from Cobalt, Ont., nickel oxide from Coniston, Ont., Glauber salt from the saline lakes of Western Canada, natron (natural crystal soda) from Brit. Columbia, and the best feldspars on the American continent are claimed by Canada. H.H.S.

Ceramics. ANON. Report of Mines, Nova Scotia, pp. 108–15(1926).—This report gives description of the various clays used by the 7 clay works of Nova Scotia, which are reviewed. The products of these plants include: (1) Steven Brooks plant, New Glasgow sand bricks, fire brick, arch and wedge brick and checker fire brick for kiln floors; (2) G. Brooks plant, New Glasgow: plain wire-cut brick and tapestry finish brick, also land tile; (3) Miller plant of Lantz red building bricks; (4) N. S. Clay Works, Lantz: bricks, land tile, and hollow building blocks; (5) Nova Scotia Clay Works of Pugwash: capacity of 1,000,000 brick per month; (6) Shaw plant at Avonport: hollow building tile, interlocking tile, partition tile, agricultural tile and brick; (7) Standard Clay Products, New Glasgow, various vitrified or glazed wares, sewer pipe, flue linings, chimney tops, building blocks according to specification, and segmental sewer blocks. This Company also makes fire brick and stove linings. The report is illustrated with cuts. O.P.R.O.

Fire clay. W. R. D. JONES. *Iron Coal Trades Rev.*, **114,** 563(1927).—A fire clay which is largely used by a steelworks in South Wales, and from which excellent bricks, nozzles, sleeves, tuyeres, etc., are manufactured after addition of various amounts of ground silica rock (20% for the manufacture of tuyeres and 5% for bricks), has the following percentage composition: $AlO_2$57.98, $Al_2O_3$26.27, $Fe_2O_3$2.31, CaO0.49, MgO104, K_2O2.48, Na_2O 0.38, loss on ignition, 8.81 O.P.R.O.

Silica. W. R. D. JONES. *Iron and Coal Trades Rev.*, **114,** 563(1927).—Silica outcrops skirt practically the whole of South Wales coal field. Those outcrops worked still have enormous reserves, and large areas have not yet been exploited. Results of numerous analyses show that the materials used for making silica bricks are practically identical in regard to chemical analysis; the silica averages above 95%, alumina content, from 2 to 1½%, the oxide content under 1%, lime, magnesia, and alkali low throughout. The published trade analysis of a local firm's best silica brick, compared with J's analysis of their raw material:

	Raw material Per cent	Fired brick Per cent
Silica	96.55	95.30
Alumina	1.54	1.52
Ferric oxide	0.53	0.52
Lime	0.20	1.76
Magnesia	0.19	0.19
Potash and soda	0.65	0.64
Loss on ignition	0.40	—
	100.06	99.93

(Proceedings South Wales Inst. of Engineers) O.P.R.O.

Glauber salts. ANON. *Continental Met. Chem. Eng.*, **1**, 116(1926).—Karabugas is a gulf of the Caspian Sea of an area approximately 3,500 sq. km. At temperatures of +5°C and below, the water of the gulf is saturated with Glauber salt which, after crystallizing, is cast out upon the beach where it is collected. This raw salt is of excellent quality, free from sand, iron, and organic substances. Analysis yields 45.45 Na_2SO_4, 54.4 H_2O, and 0.03 $MgSO_4$ and $CaSO_4$. The high amount of water contained is reduced by the action of sun rays. The very high degree of purity of the Karabugassian Glauber salt makes it particularly suitable for use in the glass industry, although other uses have also been considered. O.P.R.O.

Talc deposits of Canada. M. E. WILSON. Can. Dept. Mines, *Econ. Geol. Series*, No. 2, 128 pp. (1926).—The uses of talc and soapstone are shown in tabular form. The geologic features and geographic distribution of talc are described, and 3 classes recognized: white or light gray high-grade associated with dolomite, gray, or green with basic igneous rocks; and micaceous in veins cutting soapstone or serpentine. More than 70 deposits and occurrences are described. (*C. A.*)

Some feldspathic materials of the Pacific Northwest. HEWITT WILSON. Bur. Mines, *Repts. Investigations*, No. 2794, 13 pp. (1927).—Occurrence, composition, sampling, preparation, testing, and analysis are given. (*C. A.*)

BOOKS

Supplement to introduction to sedimentary petrography. H. B. MILNER. New York: D. Van Nostrand, 1927. Price $3.50 H.H.S.

Transactions of the American Geophysical Union, 1926. Washington: National Research Council, 1927. Price $1.25. H.H.S.

The age of the earth. A. HOLMES. London: E. Benn, Ltd., 1927. Price 6*d*. H.H.S.

Chemistry and Physics

Discussion on "Specific heats and thermal reactions of clays." W. M. COHN AND A. E. MACGEE. *Jour. Amer. Ceram. Soc.*, **10** [5], 347–56(1927).—Due to variation in specific heats obtained by C. and M., a criticism and comparison of the results is set forth by C. Methods of determination of specific heat, accuracy claimed for the methods, erroneous assumptions, and several other items are taken up in detail in the 14 sections of the discussion. The reply by M. takes up in detail each of the points raised.

An automatic device for taking motion pictures at regular time intervals. F. G. KEENEN, G. W. BENNETT, AND W. G. FRANCE. *Jour. Amer. Ceram. Soc.*, **10** [5], 435–37(1927).—An automatic apparatus for taking single photographic exposures at regular intervals of time over periods of from 12 to 36 hours was constructed. It consists of a large air thermostat and 3 mechanical units: (1) the thermal regulator, (2) the illuminating and optical system, and (3) the automatic mechanism controlling the camera and illuminating system. A detailed description of the apparatus is given.

Studies in porosity and permeability characteristics of porous bodies. W. L. HOWE AND C. J. HUDSON. *Jour. Amer. Ceram. Soc.*, **10** [6], 443–48 (1927).—Definitions are given of porosity, permeability, and weight per unit volume. It is shown that these 3 terms are not synonymous, and that a change of permeability is not necessarily accompanied by a change in porosity.

Solution of fused aluminous materials. R. W. ELLISON. *Jour. Amer. Ceram. Soc.*, **10** [6], 463 (1927).—A modification and combination of 2 fusion methods used in the decomposition and dissolving of fused aluminous materials preliminary to analysis is presented as giving none of the troubles encountered with either of the separate fusions.

Röntgenographic research on aluminum silicates. P. ROSBAUD. *Glastech. Ber.*, **4** [8], 297–302 (1926).—The 3 modifications of the compound Al_2SiO_5, cyanite, andalusite, and sillimanite, mullite ($3Al_2O_3$–$2SiO_2$), and the analagous compound pseudobrookite, $Fe_2.TiO_5$, are studied with the X-ray. The work is done in 2 phases: (1) the determination of their crystal measurements; (2) determination of the reflecting planes and space lattices. The discussion of the results points out that cyanite is a four-fold polymer, andalusite a dual polymer, and sillimanite is not polymerized; that there is no crystalline phase of the composition $3Al_2O_3$–$2SiO_2$ existing rather it is of the composition Al_2O_3–SiO_2. E.J.V.

Heat technologic work measurements. F. KRETZSCHMER. *Glastech. Ber.*, **4** [10], 361–72 (1927).—In a discussion of instruments and apparatus used in making work measurements in heat technology the following points are taken up: (1) clearness of measurements, (2) grouping of principal and subordinate measurements avoids division of attention, (3) similarity and clearness of manufactured forms clarifies the conception of the measurements, (4) comprehension of service and measuring organs saves futile routine work and guarantees careful attention, and (5) the recorder should show plainly the connection between processes which work together. E.J.V.

Equilibria in systems of silica, alumina, lime, and soda. WILHELM EITEL. *Glastech. Ber.*, **4** [11], 421–25 (1927).—A discussion of the binary and ternary systems composed of the members silica, alumina, lime, and soda, which have been studied. The outstanding features of each of the systems are pointed out. The greatest interest of the glass technologists lies in the soda-lime-silica system, that of the cement technologists in the lime-alumina-silica system, and of the ceramists in the alumina-silica system. A survey of glass, cement, and ceramic manufacture which would be possible form a single basic system would require a study of an extremely complicated system. The study of the 4 component soda-lime-alumina-silica system would probably be of the greatest immediate value as one quaternary system but others including potash, magnesia, ferrous and ferric oxides would have to be made also in order to make our knowledge of the physico-chemical reactions complete. E.J.V.

G. Tammann's doctrine on the structure of mixed crystals. E. KORDES. *Glastech. Ber.*, **4** [11], 425–28 (1927).—A discussion of G. Tammann's work on mixed crystals of silver and gold, and silver and palladium, and his diagrammatic representation of crystals of various compositions showing crystal structure, based on his publication "The Chemical and Galvanic Properties of Mixed Crystals and Their Atom Distribution." E.J.V.

On the determination of iron in red lead. LUDWIG SPRINGER. *Glastech. Ber.*, **4** [12], 458–67 (1927).—Various methods used to determine the iron in red lead are described. A comparison of results obtained by the different methods is made. The tests were made with 4 different red leads from one crystal glass factory, several other kinds of red lead from other crystal glass factories, and with a red lead from a chemical factory. Results are given and a full discussion thereof given. E.J.V.

New investigations on the system Al_2O_3–SiO_2. WILHELM EITEL. *Ber. deut. keram. Ges.*, **7** [6], 351–53(1926).—A discussion of the thermochemical work of Bowen and Greig and the X-ray work of Mark and Rosbaud on this system. F.P.H.

The softening of clay by heat. GUSTAV KEPPELER. *Ber. deut. keram. Ges.*, **7** [2], 88–100(1926).—K. discusses the difference in the softening of substances like clay refractories and silica brick. In the former the softening extends over a wide temperature while in the latter the interval is narrow. An apparatus for determining the softening point of substances is described. The substance to be tested is formed into a small pellet and placed in a furnace. A small rod of sufficient length to extend out of the furnace is placed on the pellet. When the material melts the rod sinks and breaks an electrical contact and the temperature is taken as the melting point of the material tested. K. discusses the NaCl–Na_2SO_4 system and the Al_2O_3–SiO_2 system. The softening points of clay-corundum and clay-quartz mixtures are considerably lower than the crystallization temperatures obtained for the Al_2O_3–SiO_2 by Bowen and Greig. From this K. concludes that the curves obtained by Bowen and Greig are not melting point curves but solution curves. K. discusses the 3-component system CaO–Al_2O_3–SiO_2 as worked out by Rankin and Wright. F.P.H.

The rational analysis of clays. F. STEINBRECHER. *Ber. deut. keram. Ges.*, **7** [6] 321–40(1926).—The following 2 methods of rational analysis of clays are discussed: (1) the decomposition of kaolin by means of sulphuric acid, the method of E. Berdel, (2) the decomposition of clays by heat and solution of Al_2O_3 by means of hydrochloric acid, the method of Kallauner and Matejka. The limitations of Berdel's method are pointed out. The method of Kaullauner and Matejka consists of heating the clay to about 800°C for several hours and dissolving it in hydrochloric acid. The soluble alumina is determined by removing the small amount of SiO_2 that dissolves and precipitating the alumina with ammonia. The solubility curve reaches a maximum at about 800°C for most of the clays. The effect of mica and feldspar on the results is discussed. A table showing the chemical composition, mineralogical composition as calculated from the chemical composition, and rational composition of 12 clays is given. The rational composition as determined by the method of Kallauner and Matejka (*Sprechsaal*. No. 25 (1914)) agrees well with the mineralogical composition. F.P.H.

Research and test methods for ceramic raw materials and ceramic products. ANON. *Ber. deut. keram. Ges.*, **8** [1], 44–57(1927).—Report of the materials-testing committee of the German Ceramic Society on methods of testing raw materials and ceramic products is given. Each test is described and the literature pertaining to the method is given. The following tests are considered: (1) determination of compressive strength of cylinders, (2) determination of compressive strength of plates, (3) tensile strength, (4) torsional strength, (5) bending strength and modulus of elasticity, (6) impact strength, (7) resistance to abrasion, (*a*) drum test, (*b*) grinding test, (*c*) sand-blast test. Directions for the determination of thermal properties of especially prepared test pieces (1) heat expansion, (2) specific heat, (3) heat conductivity, (4) resistance of bodies to sudden temperature changes. F.P.H.

Apparent and actual calorific value. D. J. HUDLER. *Feuerungstech.*, **15** [5], 49–52(1926). F.P.H.

Apparatus for the determination of steam in gases. H. STRACHE AND J. CARMAN. *Feuerungstech.*, **15** [11], 121–22(1927). F.P.H.

An improved metal calorimeter for the determination of the specific heat of metals, oxides, and slags. WALTER GROSSE AND WALTER DINKLER. *Stahl und Eisen*, **47** [11], 448–53(1927).—A description of a metal calorimeter suitable for specific heat measurements over the temperature interval 100 to 1600°C. The apparatus consists of 2 principal parts: (1) a constant temperature furnace where the test piece is heated

to the desired temperature and (2) a calorimeter for receiving the test piece after it has been heated to the desired temperature and measuring the quantity of heat contained in the sample. The furnace is a vertical tube wound with suitable resistor material and properly insulated. The calorimeter is placed directly under the furnace and insulated from it. The apparatus is arranged so that the sample can be discharged from the furnace directly into the calorimeter with a minimum loss of heat.

F.P.H.

The determination of silica in ores, slags, fluxes, and refractory materials in the presence of fluorine. A. STADELER. *Stahl u. Eisen*, **47** [16], 662–64 (1927).

F.P.H.

Research on the lime-silica-alumina (Portland cement) system. W. C. HANSEN, W. DYCKERHOFF, F. W. ASHTON, AND R. H. BOGUE. *Rock Prod.*, **30** [8], 64–67 (1927).—An investigation of the compound $8CaO.Al_2O_3.2SiO_2$. The following summary of this work is given: (1) Tests were made of melts of the composition: $8CaO.Al_2O_3.2SiO_2$ in order to establish whether a compound of this description was existent. A crystalline phase was obtained by melting the sample in the oxyhydrogen flame whose appearance differed from all those ordinarily encountered in mixtures of lime, silica, and alumina. By means of more satisfactory devices an equilibrium was established by producing adequate heating conditions which conformed to the data given by Rankin and Wright. (2) Double refraction, refractive index, and X-ray spectrum were the same as obtained for pure samples of tricalcium-silicate. A similar phase appeared in mixtures of 8 $CaO.Fe_2O_3.2SiO_2$ under similar conditions. (3) X-ray photographs and observations made with strongest magnification showed that the samples were not homogeneous, but that different crystalline materials were present. (4) All of these observations contradict the assumption that a ternary compound of the composition 8 $CaO.Al_2O_3.2SiO_2$ is present in this system in stable equilibrium, or that a mixed crystallization appears in this part of the 3-component system between lime-silicates and aluminates. (5) The conclusions drawn from these tests indicate that the needle-shaped crystals which were designated in previous publications as a ternary compound, consist of tricalcium silicate.

F.P.H.

Progress of inorganic chemistry. H. V. A. BRISCOE. *Ann. Rept. Chem. Soc.*, **23**, 48–73 (1927).—Subjects of general interest include several cases of apparent transmutation of elements (H to He, Hg to Au, Pb to Hg and Tl), further work on the hydrides of B (borates B_2H_4, B_2H_6, B_2H_8, B_5H_9, B_5H_{11}, $B_{10}H_{12}$), and the discovery of "illinium." Of more interest to ceramists are the following: The setting of plaster of Paris occurs in 2 stages: (*a*) a slightly exothermic absorption with contraction in volume, and (*b*) a markedly exothermic reaction between the adsorbed liquid and the absorbent with increase in volume. Accelerating cations in this change are in the order $K > NH_4 > Na > Li > Zn = Cu > Mg$; decelerating anions are $I > NO_3 > Br > Cl$. Simple dissociation of $CaSO_4$ begins at 960°; in an equimolecular mixture with amorphous SiO_2, dissociation begins at 870°. New silicides are CaSi, melting point 1220°, $CaSi_2$ melting point 1020°, Ca_2Si melting point 920°, Mg_2Si melting point 1070°, MgSi. SiS_2 (melting point 1090°) is prepared by heating sand with Al_2S_3 in a current of N, and is separable from SiS by its different volatility. Three distinct Al hydroxides of formula $Al(OH)_3$ have been obtained. By heating any of these in a sealed tube at 250° with 10% NH_4OH, the metahydroxide AlO.OH is formed; it is neither base nor acid, but shows remarkable ability to adsorb enzymes selectively. Several fluoaluminates have been prepared, and a new K salt $AlF_3.2\,KF.2H_2O$. Pure CF_4 has been isolated, boiling point minus 150°. Pure graphite melts at $3845 \pm 45°$ Abs.; pure Zr at 2200° Abs., density 6.5. In the course of experiments on silicic acids, it was found that a certain form of silicic acid is volatile in steam. Two anhydrous Tl silicates are obtained as white amorphous precipitants by adding Na metasilicate to an excess of a Tl salt. The preparation of

$2BaO.3V_2O_5.12H_2O$ has been described, and from this salt similar vanadates of Ni, Co, Cu, Be, Cd, and Mn may be obtained. Chromates of Cr are Cr_5O_{12} and Cr_5O_{13}, the latter made by heating Cr_2O_3 at 265°. Three selenic-uranic acids, and their K and NH_4 salts, have been prepared. H.H.S.

Progress in crystallography. W. L. BRAGG. *Ann. Rept. Chem. Soc.*, **23,** 257–79(1927).—B. regrets that in the article on X-ray diffraction data in the International Critical Tables, R. W. G. Wyckoff has replaced the time-honored and generally accepted Schoenflies notation of space groups by a system which he has devised himself and which requires his book "The Structure of Crystals" as a key. The subjects selected for special treatment in B.'s report are the dynamics of the crystal lattice and the intensity of X-ray reflection. He welcomes Hermann Mark's book in German on the application of X-rays to chemistry and technology. Of special interest to ceramists are the references to inorganic crystals, crystalline SiO_2, Carborundum, precious stones, etc. H.H.S.

Estimation of fluorides. J. J. FOX AND B. A. ELLIS. *Ann. Rept. Chem. Soc.*, **23,** 186, 188, 196–98(1927).—The methods of Berzelius (CaF_2), Steiger (bleaching effect on Ti color with H_2O_2), Starck (PbFCl), Greeff (M_2FeF_6) and Pisani (Th $F_4.4H_2O$), are summarized. Berzelius gives low results; sulphates, acidity, and temperature must be considered in Steiger's method; phosphates interfere with Pisani's. The difficulty from phosphates, etc., in slags has been overcome by Warren and associates(1925) by fusion and treatment with Ag_2SO_4 in the dark and with other precautions. A new colorimetric method (de Boer and Basart, 1926) depends on the bleaching of the blue lake produced by $ZrOCl_2$ with Na alizarin-sulphonate in HCl. The method applies to fluoborates, fluotitanates, fluosilicates, and fluoaluminates. H.H.S.

Heat of formation of the ferrates of calcium. N. M. YASUIRKIN. *Ann. école super. agr. amelioration Don* (*Russian*) **6,** 57–60(1925).—The heat of formation of $2CaO.Fe_2O_3$ equals 32.03 calories; $4CaO.Fe_2O_3$ 2.9 calories; $CaO.Fe_2O_3$ 1.5 calories; $3CaO.Fe_2O_3$ 6.9 calories. The heat of dissociation of $CaCO_3$ used in calculating the data was taken as 427 calories per gram. (*C. A.*)

Artificial ramsayite. A. S. GINZBERG AND CHR. S. NIKOGOSSIAN. *Bull. Com. Geol. Leningrad,* **43,** 397–408(1924) (French résumé, 407–408); *Mineralog. Abs.*, **3,** 163.—After fusion of SiO_2, TiO_2, and Na_2CO_3 in the proportions to give $Na_2Si_2Ti_2O_9$, a black, crystalline brittle mass of artificial ramsayite resulted on slow cooling. It has a specific gravity of 3.47 and melting point of 624°. The crystals show parallel extinction plus elongation, cleavage parallel to elongation, high n and birefringence. A, *calcium-ramsayite* ($CaSi_2Ti_2O_9$) was also prepared. (*C. A.*)

A reversing electric p_H indicator. E. W. TODD. *Facts about Sugar,* **22,** 14–15, 17(1927).—An apparatus is described which has been successfully used on blow-up thick juice tanks in a beet-sugar factory. It continuously indicates and, when desired, records the p_H of moving liquids through the electric current produced between two electrodes (one of Fe and one of an alloy of Sb (50 parts) and Cd (2–3 parts)) by the reaction of the solution surrounding the electrodes. The apparatus is provided with a device for automatically compensating for variations in temperatures of the solution whose p_H is being measured. (*C. A.*)

The mechanics of adsorption and of the swelling of gels. C. TERZAGHI. Fourth Colloid Symposium Monograph, pp. 58–78(1926).—An attempt to explain the relationship between the elastic expansion of coarse-grained soils and the swelling of elastic gels. Striking discrepancies are to be found between values for swelling pressure calculated by the thermodynamic formula of J. R. Katz and determined by the empirical edemetric formula of Freundlich and Posnjak. Allowing for the fact that different gelatins were used and also that Freundlich omitted the volume occupied by the solid matter of the gel, the curves belong to different families. Viscosity and surface tension

of water in capillary voids are larger than normal, which latter Herzog's formula indicates to be 8 times normal. Harkins' pressure hypothesis is discussed, 2 contradictory facts being (1) that molecular attraction by pore surfaces is limited to a sphere of the order of molecular diameters, and (2) lowering of the vapor pressure indicates a *tension* in the liquid. Furthermore, observations on permeability of clays do not agree with the hypotheses. But since as Harkins showed, adsorption involves increased density of the liquid phase, another explanation must be found. Considering the adsorbed layer as a zone of forced vibrations, the effect of the solid phase is similar to undercooling, and it extends much beyond molecular range. This mechanical tension can account for increased density and viscosity of the liquid; also for vapor pressure changes. Following a discussion of the vapor pressure, heat of swelling, and free energy of gels, it is concluded that vapor pressure lowering is due to 2 essentially different causes (1) tension in the liquids, representing the capillary or macromechanical part of the swelling process; (2) a change in the molecular energy of the liquid, representing the molecular mechanical part of the adsorption process. The importance of the second factor diminishes with increasing water content in the gel; but with increasing concentration the first factor is dominant, and then the heat of swelling is almost exclusively due not to liquid friction, but to a change in molecular energy revealing itself as a density change. Hence concentrated gels resemble solutions. (*C. A.*)

Observations on rational analysis. G. A. KALL. *Keram. rund.*, **34**, 58 (1926).—K. found that with the method of H. Ballenbach ("Lab.-Buch f.d. Tonindustrie," 1910, p. 29), for rational analysis the values found for the amounts of clay substance, quartz, and feldspar present were incorrect owing to the presence of mineral impurities. The following observations were passed on the method of H. Backe (*Keram. rund.*, **34**, 20, 1926): (1) The repeated evaporations of hydrofluoric acid from a 30 to 40 cc platinum crucible on a water-bath which took 10 to 12 hours for the complete decomposition of a fine sand could be done in 5 hours by using a 150 cc platinum dish on an air-bath and covered with a larger platinum dish kept filled with cold water. (2) A temperature of 300° was insufficient to drive off the sulphuric acid and the last trace of hydrofluoric acid which clung tenaciously, so that the dish had to be heated to a dull red heat. Aluminium sulphate was incompletely precipitated by ammonia and ammonium chloride or ammonium nitrate in the presence of hydrofluoric acid or its salts. Any magnesium was weighed up with the alkali sulphates. After removing the sulphate with barium, ammonium, and ammonium carbonate, K. had removed the magnesium by the mercuric oxide method. (3) Compared with results calculated from chemical analyses of clays, rational analyses by the methods of Berdel and Kallauner-Matejka gave low values for the feldspar contents. Backe's method gave results that were higher than could be explained by the weighing up of the magnesium with the alkalis. (4) Backe's method of calculating the amount of clay substance by the total amount of alumina, iron oxide, and titania led to erroneous results. (5) Rational analysis by Berdel's method required from 3 to 4 days. K. helped matters by decanting after 2 hours' boiling with hydrochloric acid and avoiding loss of particles of feldspar and quartz by filtering on the suction pump through a double filter of baryta and a platinum cone. The filter was then burnt in a platinum spiral and its residue returned to the porcelain dish. He had not noticed any appreciable attack by sulphuric acid on the glaze of good Berlin porcelain. The rational analysis could be done in a day by using a thick-walled 800 cc glass beaker in a centrifuge. Details of this method were given. (6) Some Tirschenreuth kaolin was subjected to 3 methods of rational analysis. The chemical analysis gave the following results: loss on ignition, 12.31%; SiO_2, 47.38%; Al_2O_3, 37.54%; Fe_2O_3, 0.34%; TiO_2, 0.29%; CaO, 0.68%; MgO, 0.1%; alkali oxides, 1.38%.

Method	Rational Analyses Clay Substance %	Quartz %	Feldspar %
Berdel	92.57	6.56	0.87
Kallauner-Matejka	92.41	6.59	1.00
Backe	93.01	—	8.05

The methods of Kallauner-Matejka and Berdel gave useful results. The Kallauner-Matejka method was the quicker and yielded consistent results. K. could not get results free from errors when using Backe's method. (*Jour. Soc. Glass Tech.*)

Microscopic researches on feldspars. V. N. Lodachnikov. *Mem. Soc. Russe Min.*, **52** [2], 61–144 (1925); *Mineralog. Abs.*, **3**, 195.—Optical data are used to determine the chemical composition of 390 plagioclases and 102 K-Na feldspars. Conclusion: There is no essential difference between orthoclase, microcline, and anorthoclase. (*C. A.*)

Refractive index diagram for potassium-sodium feldspars. D. S. Belyankin. *Mem. Soc. Russe Min.*, **52** [2], 176–219 (1925); *Mineralog. Abs.*, **3**, 197.—A diagram showing the relation of the *n's* to chemical composition of K–Na feldspars is given. (*C. A.*)

Solution of bauxite in caustic soda without pressure. B. Neumann and O. Reinsch. *Z. angew. Chem.*, **39**, 1542–45 (1926).—Pressure is in itself not necessary for the solution of bauxite in the wet way, for the same results may be accomplished by using a more concentrated solution of caustic so the temperature may be raised to 160–165°. Below this temperature the proportion of bauxite dissolved depends on both temperature and concentration. (*C. A.*)

A simple kinetic theory of viscosity. J. S. Dunn. *Trans. Faraday Soc.*, **22**, 401–405 (1926).—From analogy with diffusion of gases through metals D. derives the expression: Fluidity $= Ae - Q/T$. Logarithms of fluidities plotted against reciprocals of absolute temperatures gave straight line for many esters. A more exact equation agreeing with experimental data, is: $\log \phi = -(Q/T) + P \log T + K$. Q may be identified with the quantity of energy which it is necessary to impart to any molecule in order to overcome the attraction to all its neighbors and is greater in double or associated molecules and varies in a regular manner in homologous series. If the log of vapor pressure is plotted against fluidity a straight line is usually obtained, whose slope measures the ratio of the latent heat of vaporization to the latent heat of internal loosening. (*C. A.*)

Capillarity and wetting. II. Karl Schultze. *Kolloid-Z.*, **40**, 12–16 (1926).—The wetting process is strictly that of a liquid spreading over a smooth surface. In other cases wetting is connected with capillary filling processes. In glass, agar, and gelatin capillaries these filling processes have been investigated in their dependence on the cross-sections and positions of the capillaries and on the surface tension of the liquids. In the permeation of granular surfaces as in small grain piles, wetting was not a question of friction phenomena and resulting decreasing velocity and height of capillary rise but of restraint due to the filling of the nonvertical capillary spaces with liquid. The flotation of powders is likewise attributed to the difficulty of filling the capillary spaces. (*C. A.*)

Adsorption equations. A review of the literature. Enoch Swan and A. R. Urquhart. *J. Phys. Chem.*, **31**, 251–76 (1927).—All the various equations that have been proposed to represent adsorption phenomena are collected and their applicability to actual adsorption systems is discussed. The headings are: *General Adsorption Equation, Isotherm, Isobar, Isostere, Rate of Adsorption, Heat of Adsorption*, and *Conclusion*. A bibliography of 117 references is included. (*C. A.*)

Geochemical distribution laws of the elements. VIII. Researches on the structure and properties of crystals. V. M. Goldschmidt. *Skrifter Norske Videnskaps—*

Akad. Oslo. I. Matemat. Naturv. Klasse, **1926,** No. 8, 7–156(1927).—A monograph reviewing and classifying the results of X-ray crystal structure analysis upon the basis of coördination number, the relation between chemical composition and crystal structure, and the hardness of crystals. (*C. A.*)

Mechanism of crystallization in the solid state. P. I. LEBEDEV. *Reports Don State Univ., Rostov-on-Don*, **5,** 15–24(1925); *Mineralog. Abs.*, **3,** 164.—$BaSiO_3$ is dimorphous. Orthorhombic crystals with a strong birefringence develop in crystals of the other modification. Slow cooling results in a larger proportion of the orthorhombic form. The transformation takes place in the solid material. Microscopic characters of thin sections of melts of $BaSiO_3$ and of $CaSiO_3$ and of $CaSiO_3$+CaS are described. (*C. A.*)

The crystal structure of magnesium di-zincide. J. B. FRIAUF. *Phys. Rev.*, **29,** 34–40(1927).—The crystal $MgZn_2$ was found by X-rays to have hexagonal axes with $a=5.15$ A. U. and $c=8.48$ A. U., the unit cell containing 4 mols. (*C. A.*)

X-ray analysis of clays. L. B. STRUTINSKI. *Jour. Russ. Phys. Chem. Soc.*, **58,** 314–25(1926).—The X-ray examination of clays affords an accurate means of determining the relation between the size of the particles and the cohesive properties of the clay. The X-ray K_α (line of copper) photographs of a variety of Russian clays, both plastic and rigid, including pure kaolin, were investigated. The presence of comparatively large crystals of quartz was detected. The kaolin, which was coarse-grained even when ground, gave a characteristic diagram, some lines of which persisted in all the clays, which was due to its space-lattice. The constants of this were calculated, and several possible structures discussed. A symmetrical molecule, suggested by Samoilov, is adopted. The broadening of the lines in the X-ray photographs are measured, and the size of the particles calculated from these data. Most of the clay consists of particles larger than 10^{-5}mm., *i.e.*, the proportion of colloid is comparatively small, and the change in the X-ray diagram must be due to the deformation of the space-lattice. (*Brit. C. A.*)

Apparatus for the determination of the apparent specific gravity and of the porosity of porous materials. H. HERBST. *Chem. Zeit.*, **50,** 49(1926).—A sketch of the apparatus was given; a small bulb was used as the weighing vessel, which it was possible to evacuate to any given pressure through one tap, and later to fill with mercury by means of another tap. Thus after the original calibration the weighings were reduced to 2 per sample. If $(b+a)$=the weight of the bulb and test-piece together, $(b+g_1)$=the weight of the bulb full of mercury, $(b+g_2)$=the weight of the bulb, test-piece, and mercury, then the apparent specific gravity would be $s=13.546\left(\frac{a}{g_1-g_2+a}\right)$ and thd porosity $p=100(d-5)/d\%$. (d=true density of material.) (*Jour. Soc. Glass Tech.*)

Analysis of sulphur dioxide in the presence of excess air. E. D. RIES AND L. E. CLARK. *Ind. Eng. Chem.*, **18,** 747(1926).—The methods usually employed for the analysis of SO_2 in the presence of excess air were investigated thoroughly, and the following procedure was finally adopted as yielding results of great accuracy: The SO_2 was absorbed by bubbling through 10 cc of a 10% solution of sodium hydroxide, 0.002M in stannous chloride, contained in a modified 4 bulb Mitscherlich absorber. The solution was washed into a flask, diluted to 50 cc, cooled, then 50 cc of 12 N-HCl were added, again cooled and 2 cc of carbon tetrachloride added as an indicator. (No loss of SO_2 by vaporization occurred with small quantities, although there was danger of such loss.) Titration was then made with approximately 0.003M-potassium iodate, the solution in the flask being shaken vigorously meanwhile until the pink color of the tetrachloride disappeared, the end point being determined within 1 drop. It was necessary to run a blank determination to determine the correction for the catalyst. (*Jour. Soc. Glass Tech.*)

Advances in the manufacture of works and laboratory apparatus made from glass and ceramics. R. SCHMIDT. *Keram. Rund.*, **34,** 189(1926).—*Works Apparatus.*—The Jena works now produce quartz glass plates weighing 75. kg. and measuring 120 by 60 by 4 cm. Quartz glass is now being used for Glover towers and for Kessler-Benker sulphuric acid concentration plants. Schott's latest boiler gage glass "Maxos" resisted heat, pressure, and impact better than "Durobax" which had been marketed for 14 years. Its life was 5 times that of ordinary gage glass, which soon became opaque owing to the attack of hot water and steam. It could withstand a greater hydraulic pressure than "Durobax," which gave at 31 atmospheres pressure with cold water. Schott's "Minosglas" had a high dielectric constant, withstood high voltages, had a low conductivity and a low dielectric loss, and a sufficiently good chemical and mechanical resistance. The new Schott electrolyte counter for direct current was made of high quality Jena glass, and porous sintered glass plates were used to separate the anode and cathode spaces. Basalt, melted and slowly cooled, was an excellent substitute for lead for containers. It could be cast when hot, was harder than granite, resisted acids, alkali, salts, and oils, had a high compressive strength, (6000 kg/cm.^{2}), and low permeability, and therefore was gas- and water-proof, and a good insulator for heat and electricity. Filter plates made from kielseguhr were manufactured in many forms and grades. *Laboratory Apparatus.*—The analyzing quartz lamp was a mercury vapor lamp which embodied Uviol melted quartz filters. The latter suppressed the visible spectrum, but transmitted ultra-violet light between the wave lengths of 400 and 300 $\mu\mu$, and also allowed the mercury vapor to be heated to a high temperature. When directed on certain substances, the ultra-violet rays caused a characteristic fluorescence. Among the many uses of the analyzing quartz lamp were the detection of spurious bank notes, the identification of precious stones and pearls, the differentiation of cotton from silk, and of vegetable oils from mineral oils. Many uses for Jena glass filter plates were cited. These were made in Jena Apparatus Glass 20, normal glass 16^{III}, and the brown Fiolax glass 1495^{III}. Large Buchner funnels were made of Suprax, which had a very high thermal resistance except when for use with alkalis, when glass 20 was used. Some glass filters were also colored cobalt-blue for work with white precipitates. For very high temperatures, melted rock crystal was used. Resista glass was good against acids and water, but not against alkalis. Other forms of glass apparatus mentioned were the Zeiss color comparator, the Zeiss "Stufen" photometer, the Schnell extraction apparatus, the Xylene automatic measuring and revolution apparatus for water estimation, Rischbieth's universal hotwire gas pipette, Hahn's apparatus for the separation of arsenic from antimony, Hahn's gas-development apparatus, Rojahn's vacuum adaptor with heating and cooling, Knorr's bacteria filter, the Otte apparatus for the rapid determination of the properties and constituents of water, Baader's universal apparatus for the examination of oil, a new manometer valve for vacuum distillation, Lindner's apparatus for determination of CO_2 and H_2O in organic substances, and X-ray apparatus. Full references were appended. (*Jour. Soc. Glass Tech.*)

The quantitative determination of alumina in silicate analysis. F. STEINBRECHER. *Sprechsaal,* **59,** 295(1926).—The following method of determining alumina in silicate analysis was proved to be accurate, eliminating errors due to the inclusion of silica with the alumina: The silica was taken down once, and the filtrate therefrom was made to 500 cc. From 200 cc of this solution the alumina was precipitated, washing being performed with a 2% ammonium nitrate solution containing 4 to 5 drops of ammonia per liter. After washing, the precipitate was dissolved in hydrochloric acid and again precipitated with ammonia. After filtering, the filtrate was in each case tested for alumina. The precipitate was ignited in a platinum crucible, cooled, and weighed. For each 0.1 gm. of Al_2O_3, 1 cc of 96% sulphuric acid was carefully added down the side of the crucible, and in a similar way 1 to 2 drops of 40% hydrofluoric acid from a

hard-rubber dropping bottle. Careful heating in an air-bath (Hillebrand) drove off all the free sulphuric acid, after which the moistening with acids and drying was twice repeated. Finally, the crucible was heated first over a small flame, then on the blast. After weighing, a further treatment with sulphuric and hydrofluoric acids gave a check of the complete removal of silica. (*Jour. Soc. Glass Tech.*)

Contribution to the knowledge of clay substance. B. NEUMANN AND S. KOBER. *Sprechsaal*, **59**, 607(1926).—Two clays used in the "fulling" of wool, a Zettlitz, a Westerwald, and a Florida kaolin were taken, and samples heated to various temperatures up to 1000°. The percentages of water lost, and of iron and alumina soluble in hydrochloric acid were determined and the results plotted for each clay. It was evident that the solubilities of both the oxides were similarly affected by ignition, and, in general, the temperature at which the solubility curve began to rise more steeply was also that at which the same occurred with the water loss curve. The Florida kaolin was somewhat anomalous, but its composition was considerably different from those of the other 4 clays. (*Jour. Soc. Glass Tech.*)

BOOK

Inorganic Chemistry. ROBERT SCHWARZ. Vol. 16 of the collection of Scientific Research Reports edited by R. E. Liesegang. x+139 pages. Published by Th. Steinkopff of Dresden, 1927. Bound in linen R. M. 9.20. S. covers the literature from 1914–1926 on experimental inorganic chemistry. The following subjects are treated: (1) new elements, (2) geochemistry, (3) molecular structure, (4) theory of the color of inorganic compounds, (5) the hydrides of the elements, (6) the nonmetals, elements of group 5, 6, and 7, (7) elements of groups 1, 2, 3, 4, and 8, (8) complex compounds, (9) the nature of secondary valence, (10) stereo-chemistry of complex compounds, (11) stability of complex nucleus, (12) complex metallic acids, (13) author index and subject index. F.P.H.

PATENTS

Process for the production of ceramic products. W. VERSHOFFEN. U. S. 1,628,522, May 10, 1927. The process of making sintered clay articles which comprises adding a soluble fluoride to the clay, increasing the free silica which may be present in the clay to an amount sufficient to ensure the silicating or cementing action of the fluoride and thereby to act as a binder on sintering, and sintering at a lower temperature than is required for the clay alone.

General

A study of some factory processes. H. M. KRANER AND E. H. FRITZ. *Jour. Amer. Ceram. Soc.*, **10** [5], 357–66(1927).—This paper deals with some ceramic plant methods and machine design which are either wasteful of labor or power. The following are discussed and in some cases actual examples existing were subjected to calculation of the waste involved. Some of these cases remedied were: (1) raw material handling, (2) small power plant costs: boiler practice and plant power factor, (3) screens, (4) steam pipes, (5) heat insulation, (6) steam jets, (7) sagger presses, and (8) steel dies.

The effect of fine grinding on an indurated clay. T. C. WALKER. *Jour. Amer. Ceram. Soc.*, **10** [6], 449–50(1927).—Fine grinding develops certain desired physical properties of a clay that has become hard by the pressure of the overlying stratas and the heat produced by this pressure. The fineness of grind produces in direct proportion an increase in the plasticity, plastic tensile strength, and shrinkage, and a decrease in the absorption and porosity. An indurated clay can be made to produce required properties by the proper fineness of grinding.

Ceramic Research Council and Institute. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **6** [5], 117–20(1927).—A proposed way of financing a Ceramic Research Council and

Institute is discussed. The need for fundamental and applied research in ceramics and ways in which this need would be taken care of by the establishment of a Research Council and Institute are shown. E.J.V.

Glass Container Association meets. ANON. *Amer. Glass Rev.*, **46** [32], 15–16 (1927).—A report of the annual meeting held in Atlantic City on May 5 and 6, 1927. E.J.V.

Container makers plan great advertising campaign to increase use of their ware. ANON. *Amer. Glass Rev.*, **46** [33], 15 (1927), *Nat. Glass Budget*, **43** [2], 3 (1927).—A full report of the 8th annual meeting of the Glass Container Assn. held at Atlantic City on May 5 and 6, 1927. It was agreed to spend $200,000 in a coöperative effort to increase use of glass containers. Frank Ferguson, the reëlected President is to launch the campaign, having been given leave of absence for 3 months, tentatively, by the Illinois Glass Co., for this purpose. E.J.V.

President Ferguson talks to Glass Container people. FRANK FERGUSON. *Nat. Glass Budget*, **43** [2], 3 (1927).—A full report of the address on the subject "Our Industry and Its Association," delivered at the Atlantic City meeting of the Glass Container Assn. E.J.V.

The Ceramic Society. ANON. *Pottery Gaz.*, **52** [599], 795–801 (1927).—The annual general meeting was held at Stoke-on-Trent on April 11, 1927. The retiring President gave various personal experiences he had met with in his factory. "Conservatism" in the potteries, unnecessary secretiveness, need for greater fuel efficiency, oil and electricity for pottery firing, and fineness of grinding were discussed. J. Sargent then presented a short paper on "Some New Heat-resisting Steels," describing tests made on types of steel which had proved nonscaling at temperatures up to 1000°C. A general discussion followed. E.J.V.

Forty-eighth annual meeting United States Potters' Association. ANON. *Pottery, Glass, and Brass Salesman*, **34** [20], 97–103 (1926).—A full report of the two day meeting held in New York on December 2 and 3, 1926. Thomas B. Anderson was elected president. E.J.V.

Ceramic Advisory Committee holds meeting. ANON. *Brick Clay Rec.*, **70** [9], 708 (1927).—A meeting of the Advisory Committee on Ceramics of the Bureau of Standards was held on March 30, 1927. The following papers were presented: (1) "The Work of the Refractories Section," by R. F. Geller; (2) "The Drying of Clays," by W. H. Wadleigh; (3) "The Study of Extrusion Machines," by P. C. Grunwell; (4) "Structural Properties of Burned Clay Products," by D. E. Parsons; (5) "The Work of the Columbus Station: English China Clays; Elasticity and Thermal Expansion of Glazes, and Properties of Heavy Clays," by T. A. Klinefelter; (6) "The Work at Columbus on Refractories," by R. F. Geller. F.P.H.

Watch your power factor. H. M. KRANER AND E. H. FRITZ. *Ceram. Ind.*, **8** [5], 540–43 (1927).—The article deals with: (1) economical handling of raw material, (2) power efficiency, (3) heat losses from steam pipes, (4) efficiency of pumps. F.P.H.

Practical pottery cost accounting. E. J. BORTON. *Ceram. Ind.*, **8** [5], 544–50 (1927).—Cost accounting methods applicable to practically all classes of whiteware plants are discussed. The advantages of accurate cost information are pointed out by B. F.P.H.

Low temperature carbonization in connection with steam boilers and other furnaces. R. MANSCHKE. *Feuerungstech.*, **15** [3], 25–27; **15** [4], 39–43 (1926). F.P.H.

The briquetting of colloidal fuel. BERGRAT WEIMANN. *Feuerungstech.*, **15** [6], 61–63, *ibid.*, **15** [7], 76–79 (1926). F.P.H.

Generator gas as a fuel for high-power and high-pressure boilers. D. J. HUDLER. *Feuerungstech.*, **15** [7], 73–76 (1927). F.P.H.

Combustion temperatures and efficient heating in gas-fired furnaces. A consideration of the value of industrial gas. E. DIEPSCHLAG. *Feuerungstech.*, **15** [9], 97–101 (1927). F.P.H.

Selection and protection of motors. H. L. SMITH. *Rock Prod.*, **30** [9], 94–97 (1927).—Characteristics of various types of motors are given and their special application is discussed. F.P.H.

Book Review

Tonindustrie-Kalender 1927. 2 vols. Chemical laboratory for the clay industry and *Tonindustrie Zeitung*. H. Seger and E. Cramer Co., Berlin. Both volumes 4.5 marks. A few of the subjects treated in the first volume are: Post rates and freight rates in Germany; simple and compound interest tables; volume and weight units; census data of principal countries of world, etc. The second volume contains material of considerable technical interest. A few of the tables presented in this volume are: atomic weight and specific weight of the elements; the Seger cone equivalent expressed in degrees centigrade; types of hollow building tile; melting point of elements and compounds, weight of various building materials; dimensions of tile manufactured by various companies; classification of kilns; temperatures reached in various industrial kilns; heat conductivities of materials; comparison of English, German, and French sieve numbers. A directory of companies offering supplies to the ceramic industry is also given. F.P.H.

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(See Bulletin this issue, page 206)

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A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical, Scientific and Art Questions and Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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Vol. 6 July, 1927 No. 7

EDITORIALS

THE NATION AND SCIENCE[1]

BY HERBERT HOOVER[2]

Business and industry have realized the vivid values of the application of scientific discoveries. To further it in twelve years our individual industries have increased their research laboratories from less than 100 to over 500. They are bringing such values that they are increasing monthly. Our federal and state governments today support great laboratories, research departments, and experimental stations, all devoted to applications of science to the many problems of industry and agriculture. They are one of the great elements in our gigantic strides in national efficiency. The results are magnificent. The new inventions, labor saving devices, improvements of all sorts in machines and processes in developing agriculture and promoting health are steadily cheapening cost of production, increasing standards of living, stabilizing industrial output, enabling us to hold our own in foreign trade, and lengthening human life and decreasing suffering. But all these laboratories and experiment stations are devoted to the application of science, not to fundamental research. Yet the raw material for these laboratories comes alone from the ranks of our men

[1] *Sigma Xi Quarterly*, **15** [1], 13–19 (1927).

[2] Secretary of Commerce.

of pure science whose efforts are supported almost wholly in our universities, colleges, and a few scientific institutions.

There is a wide difference in the mental approach of the men engaged in these two fields of scientific work. The men in pure science are exploring the frontiers of knowledge and they must necessarily do so without respect to reward or to its so-called practical benefits, whereas the men engaged in applied science research have long since demonstrated that it pays in immediate returns. It brings such direct rewards as to generate its own steam mostly through the Patent Office. There is seldom any direct financial profit in pure science research, although its ultimate results are the maintenance of our modern civilization and are the hopes for the future.

For all the support of pure science research we have depended upon three sources—that the rest of the world would bear this burden of fundamental discovery for us, that Universities would carry it as a by-product of education, and that our men of great benevolence would occasionally endow a Smithsonian or a Carnegie Institution or a Rockefeller Institute. Yet the whole sum which we have available to support pure science research is less than $10,000,000 a year, with probably less than 4,000 men engaged in it, most of them dividing their time between it and teaching.

Some months ago our leading scientists in reviewing the organizations of pure science of the country were discouraged to find that their activities had been actually diminished during the last decade, whereas if these laboratories are to furnish the increasing vital stream of discovery to our nation, and our normal part to the world, they should have been greatly enlarged. Moreover, they discovered that the pressures of poverty in Europe were taking a worse toll of pure science abroad.

These men of pure science are the most precious assets of our country and their diversion to teaching and applied science reduces the productivity which they could and should give to the nation. It is no fault of their own but it is the fault of the nation that it does not give to them and to the institutions where they labor a sufficient support.

There is no price that the world could not afford to pay these men who have the originality of mind to carry scientific thought in steps or in strides. They wish no price. They need but opportunity to live and to work. No one can estimate the value to the world of an investigator like Faraday or Pasteur or Millikan. The assets of our whole banking community today do not total the values which these men have added to the world's wealth.

And the more one observes the more clearly does he see that it is in the soil of pure science that are found the origins of all our modern

industry and commerce. In fact, our civilization and our large populations are wholly builded upon our scientific discoveries. It is the increased productivity of men which has come from these discoveries that has defeated the prophesies of Malthus. He held that increasing population would constantly lower the standard of living amongst men until the pressure of subsistence upon population would limit its number by starvation. But since his day we have seen the paradox of the growth of population far beyond anything of which he ever dreamed, coupled with a constantly increasing standard of living. This result would be impossible but for the men of fundamental scientific research and discovery. In fact, there is for the future but one contestant in the race with the principle of Malthus, and that is in pure science. If we would have our country increase in its standards of living and at the same time accommodate itself to an increasing population at the rate of more than 15 million each decade we must maintain the output of our pure science laboratories.

The wealth of the country has multiplied far faster than the funds we have given for these purposes. And the funds administered in the nation today for it are but a triviality compared to the vast resources that a single discovery places in our hands. We spend more on cosmetics than we do upon safeguarding this mainspring of our future progress.

But to return to my major theme—how are we to secure the much wider and more liberal support to pure science research? It appears to me that we must seek it in three directions—first, from the government, both national and state; second, from industry; and third, from an enlargement of private benevolence. We have long since accepted the obligation upon the state to provide universal and free education. We have advanced it further than any nation in the world. Yet the obvious function of education is to organize and transmit our stock of knowledge—it is not primarily concerned with the extension of the borders of knowledge except so far as the process is educational. It seems to me that we must accept the fact that the enlargement of our stock is no less an obligation of the state than its transmission. As a nation we must have this enlargement of stock if we would march forward. And the point of application is more liberal appropriations to our National Bureaus for pure science research instead of the confinement as today of these undertakings for applied science work. And we must have the more liberal support of pure science research in our state universities and other publicly supported institutions.

Our second source of support must come from business and industry. You are aware of the appeal in this particular from the National Academy of Sciences of a year ago—that they might be entrusted with a fund largely for the better support of proved men now engaged in

such research in our universities and elsewhere. It is no appeal for charity or benevolence. It is an appeal to self-interest, to insurance of every business and industry of its own future. That appeal has been met generously by some of our largest industries; it is under consideration by others; it has been refused by one or two largely because they have not grasped the essential difference between the applied science investigations upon which they are themselves engaged and the pure science which must be the foundation of their own future inventions. A nation with an output of fifty billion annually in commodities which could not be produced but for the discoveries of pure science could well afford, it would seem, to put back a hundredth of one per cent as an assurance of further progress.

Nor is the interest of a particular industry confined to the science research which appears on its face to be directly in the line of that industry. Practically all industry and all business gains by scientific discovery in any direction. The discoveries which led to the invention of the internal-combusion engine and thus to the automobile have benefited every industry and every business in the United States. Business and industry have an interest in the common pool of scientific research irrespective of its particular field. Those fundamental discoveries of the germ basis of disease, with the load of mortality they have lifted from the race, have lowered the rates of insurance and thus contributed directly to business.

From benevolence we have had the generous support of some individuals to our universities and scientific institutions, but this benevolence has come from dishearteningly meagre numbers, as witness the discouraging results of recent appeals from the Smithsonian—the father of American science—and failure of appeals from some of our universities. In a nation of such high appreciation of the value of knowledge, and of such superabundance of private wealth, we can surely hope for that wider understanding which is the basis of constructive action.

And there is something beyond monetary returns in all this. The progress of civilization, as all clear-thinking historians recognize, depends in large degree upon "the increase and diffusion of knowledge among men." Our nation must recognize that its future is not merely a question of applying present-day science to the development of our industries, or to reducing the cost of living or to eradicating disease and multiplying our harvests, or even to increasing the general diffusion of knowledge. We must add to knowledge, both for the intellectual and spiritual satisfaction that comes from widening the range of human understanding and for the direct practical utilization of these fundamental discoveries. If we would command the advance of our material

and, to a considerable degree, of our spiritual life, we must maintain this earnest and organized search for truth. I could base this appeal wholly upon moral and spiritual grounds; the unfolding of beauty, the aspiration after knowledge, the ever-widening penetration into the unknown, the discovery of truth, and finally, as Huxley says, "the inculcation of veracity of thought."

No greater challenge has been given to the American people since the Great War than that of our scientific men in the demand for greater facilities. It is an opportunity to again demonstrate in our government, our business, and our private citizens the recognition of a responsibility to our people and the nation greater than that involved in the production of goods or trading in the market.

CLASTICITY AND PLASTICITY

Clastic, fragmental; made up of fragments or discrete particles.

Clast or classed; petrographic classification by norms (calculated) or modes (actual).

Clays are clastic rocks, their essential constituents being discrete mineral particles. These particles are subject to breaking down and to alteration under the influence of the same mechanical and chemical agents which destroy massive rocks. Solution, oxidation, hydration, carbonation as well as the reactions caused by the plants and animals and by pneumatolysis will alter the mineral constitution of clays.

Clays differ in character according to their (1) mineral constitution, (2) size of particles, (3) accessibility to altering agents and infiltered solutes, and (4) extent and character of cementation of the mineral particles.

The kind and state of the mineral constituents are the most essential determinants of the character and the serviceability of clays. In shorter terms, the character and serviceability, differ most with the kind and state of the mineral particles, and are influenced by solutes and organic materials and by the solubility of the cementing salts by which the mineral grains are agglomerated.

The influencing factors of plasticity are producible and alterable in manufacturing processes but the basic and fundamental factor of plasticity, clasticity, is not subject to alteration in manufacturing.

Resourcefulness and success in manufacturing clay products, china and bricks alike, are dependent on a knowledge of the clay clasticity, and on knowledge of the factory means of controlling those factors which influence plasticity.

A study of the clasticity of clays will be more productive of real and immediate value to clay workers than will be a study of plasticity, for clasticity is the essential fundamental cause and plasticity an effect.

Important as is clasticity to the working properties of clays, it is of much greater importance to the properties developed by partial fusion of clay and of clay-mineral mixtures.

A knowledge of the mineral character of clays and its relation to the working properties and to the properties developable by partial fusion will be of value to all ceramic industries, clay, glass, and glass enamels.

We are emphasizing the greater importance of studying the causative property of clays, clasticity, as being fundamental to an understanding of the resultant properties such as plasticity, fusibility, vitrification range, and behavior in fusion with admixed minerals.

PAPERS AND DISCUSSIONS

THE ADVANTAGE OF GOOD DESIGN IN TABLEWARE[1]

By F. G. Holmes

ABSTRACT

Artistic design is a strong factor in the pottery industry, but is often forgotten. Sales are largely dependent upon design, rather than price, as is shown by examples cited. A plea is made for design more seriously considered, keeping away from imitation of domestic and foreign creations.

Design, is an all powerful factor in the pottery industry. The inspiration of the designer creating each piece, whether of chaste simplicity or most elaborate design determines the user's joy and pride of possession for generations. With this thought in mind, it should act as an incentive for all of us in the pottery industry to give more thought, more time to decorations that become actually a part of the home life. This should apply quite as much, even more, to inexpensive china than the more expensive makes. Because a decoration is being made in mass production, is no reason why it cannot be attractive and well-designed. The fact that it is to be used in great quantities is all the more reason why it should receive careful thought and embody color combinations that are satisfying and pleasing to live with.

By creating along conservative lines, it seems to me that it is bound to reach a greater buying public. I do not mean that a concern should not take a flier in producing lines to meet fads. Vivid color combinations, unique and fanciful designs are a necessary part of a line; they are usually made to meet some popular demand of the moment, and the manufacturer has to get a run for his money as quickly as possible, before the fad passes out.

I have often been asked how we know what will sell. We do not know. In most cases, we take a sporting chance: even more so than general-ware potteries, and we seldom mention the failures. Only the live and successful patterns are ever heard of. We have our disappointments and failures to a greater degree in producing fine china. Our purchasers are perhaps more discriminating, and if a decoration does not appeal, it gradually dies out. It may be a pattern of dinnerware that we have spent a great deal of time and money to produce, but we have no way of knowing the answer until the buyer has presented it in the store to the retail customer.

It is a peculiar thing, how some patterns will be an instant success, producing good sales, while others will be received in a cold way, and

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[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (Art Division.)

even after they have been in the line two or three years, the sales will show a gradual increase. Perhaps the best example of an unusual success or hit in dinnerware decoration, is the "Lenox Ming." Its motifs and general coloring have been adopted by American and European potteries, but our sale in Ming seems to continue on. It is sort of the Willow tree success, enjoyed by the English potteries. The Autumn Pattern, at twice the price of Ming, on account of the hand work required in the design, became a close second, which shows to some extent that price is not always a factor. I mention these because they were the two first color patterns to be brought out by the Lenox Pottery in any quantities.

Quantity with us, is not to be compared to the production of general-ware potteries. Nevertheless, there was a big demand for fine china and more than we ever expected. We did not know that these designs were going to sell. Their success was a great surprise to us. We spend an unusual amount of time in creating and bringing out a new pattern. After the idea is on paper, we discuss the practical possibilities, and color combinations are suggested; plates are decorated entirely by hand, no matter how intricate the design, so that the exact effect can be determined. Wherever color is not satisfactory, it is done over until we are pretty well satisfied that we have gone as far as possible. If it is a design requiring part process work, such as decalcomania, or lithograph prints, the final hand-made sample is used as a model and tryouts are made of sample prints and color until a perfect reproduction of the original is finally accomplished. It usually consumes eight to twelve months for us to produce a new dinnerware pattern.

The purchasing of a dinnerware service is an event of interest in most homes. Usually it is selected by the wife, but in many instances, both husband and wife take the time to go to the store, talk over their ideas with the salespeople and select something within their price and for their particular requirements. Where can a hostess display artistic taste more so than in the arrangement of her table? Quite as attractive tables can be set up with inexpensive china as with expensive, and it is up to the manufacturer to produce as fine workmanship as he knows how, designs that are a credit to his particular contribution in the pottery industry and not copies of other successes.

Manufacturers to my mind, should make every effort to keep as far away from English, German, and French creations as possible, or from imitating each other. We do not export china; our market is right in our own country, with tremendous possibilities for American-made dinnerware of all grades. Graceful forms and decorations are what we all should strive for. Artistic design sells the product. Many concerns appropriate vast sums for attractive, artistic advertising of their

product, and fail to see the importance of money being spent in the creative end of the business. Much thought is given to raw materials; clays, feldspar, and preparation. Modern potteries, with every conceivable improvement of manufacturing, have taken the place of our old time buildings and methods. Production has been given great thought, processes standardized; business systems established; yet, design plays a very important part as a controlling factor in production after all and when the finished article is placed before the retail purchaser and the sale is to be made, design, as a talking point, suddenly looms up like an electric sign. In the process of mixing the clay, it was forgotten.

The following is an extract from the *Chicago Evening Post.*

Three well-known Chicago men made known their interest in the home and the arts in lectures at Marshall Field & Company during last week. Walter Sargent, professor and chairman of the department of art of the University of Chicago, spoke on the principle of color in table arrangement. Mr. Sargent is the author of "The Enjoyment and Use of Color." Robert Lee Eskridge, well known locally for his unusual murals and decorations, spoke on exotic table settings; and Osborn Warner of the department of decorative art, Art Institute of Chicago, told how light heightens the interest of smart table decorations.

Each one of the speakers seemed to enjoy the opportunity of arranging the tables to suit himself, and the effects which they produced were a guaranty of their theories.

To contribute to the art of table setting in America, seems to be our mission, and we shall have to step out to keep pace with the evergrowing interest of the American public.

LENOX INCORPORATED
TRENTON, N. J.

SAGGER SYMPOSIUM[1]

Notes on Sagger Bodies

BY E. H. FRITZ

In the paper on sagger bodies, presented a year ago,[2] I advanced the idea that to obtain a life of fifteen to eighteen firings with a sagger body, it must have certain definite dry modulus, linear shrinkage, and absorption values. Other properties such as fired modulus and coefficient of expansion also influence the life, but regardless of how favorable these might be in a particular body, it was my thought that the other properties would always have to fall within definite limits in order to obtain long life. These limits were given for cone 10 bodies. Further work to verify this has been done and a short summary is here given.

[1] Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Detroit, Mich., February, 1927. (White Wares Division.)

[2] E. H. Fritz, *Jour. Amer. Ceram. Soc.*, 9 [9], 606–12 (1926).

The shrinkage of the best bodies described in the paper was less than 7%. The lowest was 6%. Since low shrinkage seemed necessary, we wondered if we could get further improvement with a shrinkage lower than 6%. It was not possible to get clays having sufficiently low shrinkage to give such a low body shrinkage with the usual 45 to 50% grog, and the grog content of some of the bodies previously tried was therefore increased in sufficient amount to reduce the average body shrinkage to 5½%. This necessitated the addition of some organic binder in order to maintain satisfactory dry modulus. The life was determined in the usual way. Both bodies gave the same life (eighteen firings) as was obtained before the grog was increased. Considering that these saggers were fired in a periodic kiln and that the handling of them between firings was probably rougher than is done in the average plant, it is reasonable to assume that eighteen firings is about the limit of any clay sagger under these particular operating conditions. These results, however, showed that it is possible to increase the grog content from 5 to 10% in the average sagger body with no adverse results, provided the dry modulus is maintained with an organic binder.

A sagger body was tried in which a cheap English ball clay was the plastic, tight firing constituent. To give the proper body values, some low shrinkage and open firing clays must be used with it. In this case Ohio No. 1 and Pennsylvania Colonial, both of which have been described,[1] were used. The English ball clay constituted 30% of the clay content. In this way a body was developed having a dry modulus of ninety-six pounds, a cone 10 absorption of 8.6% and a linear shrinkage of 6.2%. All of these values are within the limits proposed. This body gave a life of sixteen firings which compares closely with similar bodies previously tried.

We are, at present determining the life of a rather interesting combination of Pennsylvania Colonial clay and a fire clay very finely ground to get the maximum plasticity and bonding strength possible. The average dry modulus was still only sixty-eight pounds and organic material was therefore used. The average absorption was 8.3% and linear shrinkage 6.9%. This is a very cheap body, since the two clays are near at hand and the first cost is rather low. It is doubtful whether it would be practical because the low plasticity makes it difficult to handle in the making operation, but it will be interesting to see whether the long life which the property values indicate will be obtained.

Two bodies were tried in which 40 to 50% of the grog was substituted with some super-refractory materials. One body gave twenty-one

[1] E. H. Fritz, *loc. cit.*

firings, and the other on which the life determination is not quite complete, will not go more than twenty firings. Considering the cost of the special materials (which was from two to six cents per pound) which are substituted for grog having practically no value, we find no advantage in their use.

A few weeks ago, I obtained the cost of operating our sagger department for a five-month period in 1926. The cost of operating, including all fixed charges and other overhead, showed an average cost of 26½ cents per sagger, based on an accurate count of saggers made. By taking the number of kilns fired during this period and multiplying by 2200, which is the average number of saggers placed in a kiln, the total number of saggers fired during this five-month period is obtained. Dividing this by the number of saggers made, which is the replacement, the sagger stock being practically the same at the beginning and end of this period, the average life of our saggers is obtained. This gave nineteen firings. The life of this body previously determined experimentally, was eighteen firings. It is very gratifying to know that the results of our experimental work are being obtained on a large scale.

K. M. SMITH: How were the figures on sagger life obtained?

E. H. FRITZ: We use for test purposes one of our standard size saggers. The outside diameter is thirteen inches. We make up 100 or 125 saggers keeping a record of the actual number made. We assign these to one particular kiln, marking on them with glaze the number of the kiln in which they are to be used, and place them in the first ring in order to get the most severe operating conditions. Then we keep a record of the number of saggers that are left after each time the kiln is fired. We assume an arbitrary condition that when one-half of the saggers are gone, the number of fires they have received at that time is the life of the sagger. In other words, we do not follow the saggers clear through until they are all gone.

K. M. SMITH: If there were one hundred saggers to start with, and at the end of eighteen firings, there were 50 left, would the life of that sagger be eighteen firings?

E. H. FRITZ: Yes; this is merely a standard we have set. It does not necessarily mean that this is the life of the sagger, because many of the saggers are broken in handling, and this is not the true life of such saggers. However, some standard method must be adopted to obtain comparisons.

(W. H. Vaughan asked a question relative to the size of grog used.)

E. H. FRITZ: We are still using the same size of grog as given in the paper, "Some Successful Cone 10 Sagger Bodies."[1] We screen the grog

[1] *Loc. cit.*

through inclined screens, and it will run about 30% coarser than 3-mesh as screened in that way, and the other 70% is between 3- and 12-mesh. That which passes through the 12-mesh, screened in that way, is not used in the sagger body. I have not made any tests in regard to fired modulus. I hoped, though, that somebody here would have something along that line. Mr. Whitmer, have you had any experience with this problem?

J. D. WHITMER: We do not have the data in shape to present at this time, so we can only outline briefly our experiences.

Somewhat more than a year ago we began an intensive study of the sagger problem in our factory from a different standpoint than that just described by Mr. Fritz.

Our basis of study was the determination of the moduli of rupture after repeated firings of the available sagger clays. From these data we drew curves which visualized the behavior of the clays under these conditions. Out of a great many clays tested, we found only three which either held their own or increased in strength after repeated firings.

With these three clays we began experimenting to develop a better sagger body. The results have been very gratifying thus far. The sagger body developed was a radical departure from the type formerly used inasmuch as it was very much denser. We, therefore, tested it out very thoroughly before considering it suitable for use and even then we were slow to adopt it.

The period from October of last year until the first of this year was used as a demonstration period with such successful results that we adopted the body and put it into use January 1, 1926. Since then our sagger losses have been materially lessened.

After reading the paper Mr. Fritz presented at Atlanta last February, and as a matter of general interest, we determined the various factors he indicated as a guide and found our body in general checked his results. We did not find much difference in the shrinkage of the two bodies, but the new one was much denser than the old one. Contrary to our previously held theories, this body materially decreased our sagger breakage when used in the tunnel kilns.

The life of our sagger body does not approach that of the body you mention, although we have one trial of which about one-third of the saggers are left after the fifteenth fire. The life of this body will probably be about fifteen firings. The general average, however, would be nearer ten firings.

In our factory, the saggers are used to a considerable extent for storage purposes. They frequently are trucked for considerable distances to other departments. This use requires a sagger of high me-

chanical strength and it is very probable that a large proportion of the increased life of our saggers is due to the increased strength of this new body which enables it to withstand rough handling.

We should prefer a longer period of observation before forming any decided opinions. Next year we may be able to present some data of interest.

E. H. FRITZ: What shape sagger did you use in your tests?

J. D. WHITMER: A rectangular sagger which is undoubtedly much weaker structurally than a round sagger.

It is about 16 inches long, 10½ inches wide, and 6 inches high external dimensions. This is the sagger most largely used in our factory.

E. H. FRITZ: If the number of firings which we obtain with our saggers seems rather high it must be kept in mind that our sagger shapes are probably more favorable than the average, because they are round which gives a stronger sagger. We must always consider, too, the individual operating conditions in the plant. Mr. Whitmer's operating conditions are possibly more severe than ours, and so each plant has its own conditions which must be taken into account in setting a life which is considered fairly good for the operating conditions.

R. C. MEEKER: We have been doing some work on our sagger clays following out both Mr. Fritz's work and the ideas of Mr. Whitmer. We made up a large number of test bars, put them through a cone 10 fire, and determined the fired modulus of rupture, shrinkage, and absorption after the first, third, fifth, eighth, eleventh, and fourteenth firings.

The results of the test showed some very interesting changes which take place in the three properties, shrinkage, fired strength, and absorption, after repeated firings. We found a gradual increase in shrinkage throughout the fourteen firings. The shrinkage of the siliceous clays showed less change after repeated firing than those clays whose alumina-silica ratio was less. We found one clay which showed practically no change in shrinkage through all fourteen fires.

The changes in absorption were most rapid from the first to the fifth firings. Most of the clays showed very little change in vitrification after the fifth or eighth fire. The clay we mentioned as showing practically no change in shrinkage showed the same characteristic in absorption. The clays of the ball clay type tighten up very rapidly during the first five firings.

Mr. Whitmer said that in his experience he found some clays whose fired strength would decrease at about the fourth fire. Unfortunately we are unable to say what happens with the clays between the intervals of firing used for our determinations. We found little change in the fired strength in the first three firings, most of the clays either holding

their own or increasing slightly. The determinations at the fifth and eighth showed very great increases in strength. The eighth fire seemed to be a critical point for as a rule all clays decreased in strength from then to the fourteenth fire, which was as far as we went in our work. Only one clay showed an increase in strength through all the fires up to and including the fourteenth. All of the clays tested had a greater strength at the fourteenth firing than at the first with the exception of one which was slightly lower.

What we originally set out to do was to develop a complete sagger mix from our various sagger materials and to determine what clays should be used and the proportions of each. The advantages in receiving a satisfactory sagger mix in which all clays are accurately proportioned by weight and further blended and mixed by grinding are quite obvious, and there has long been a demand for such a product. We find that the proportions of the several clays used give a sagger mix which checks very closely the limits for absorption, shrinkage, and dry strength as given by Mr. Fritz in his paper.[1] We do not have, as yet, a record of the life of saggers for comparison with the results given in the paper. However, we have customers for mixed sagger clay whom we had never shipped to regularly, so we feel that it does have merits, and that good results can be obtained from a sagger mix similar in its properties to those sagger bodies developed in the investigations of Mr. Fritz.

E. H. FRITZ: This work of Mr. Meeker's follows out pretty closely what Mr. Whitmer is doing. The effect of repeated firing on the properties of the sagger body is of great importance and we are going to do some work on it also.

J. D. WHITMER: We adopted this method of attack because of our observations of sagger losses in actual practice.

We noticed that there appeared to be a critical period after the third firing, particularly in the fourth, fifth, and sixth firings, where the sagger losses were extremely heavy. After that period was safely passed, the remaining saggers seemed to hang on more or less indefinitely.

We reasoned that there must be a cause for this, so we evolved the idea of studying the individual clays mixed with 10- to 28-mesh grog on the basis of strength after repeated firings. From the individual clays we went to mixtures of clays and found in the main that the general tendency revealed by the individual clay was reflected in the mix.

For instance, one clay tested was a very strong plastic clay in the green state. It increased in strength for three fires, decreased in strength for three more fires, then tended to increase again.

[1] *Loc. cit*

Upon using this clay to replace other plastic clays in our newly developed mix, we found this characteristic behavior reflected in our sagger breakage which was particularly heavy in the fourth to the sixth fires. The average life of this sagger-mix was intermediate between the new mix and the old one. The added strength after the sixth fire availed nothing, as there were but comparatively few saggers left in commission. This illustration is given to indicate the probable value of the method described in forecasting the action of a clay when used in a sagger-mix.

A MEMBER: Are the saggers to which you are referring subject to light or heavy use?

E. H. FRITZ: They are used in the manufacture of porcelain insulators. An insulator, undoubtedly, does not give you as heavy loading as tile, but possibly an average loading, because the sections are often quite thick.

J. D. WHITMER: Our sagger load varies from very light to very heavy.

E. H. FRITZ: Have you found that thickening up the bottoms of the saggers helps somewhat on the heavy loading?

J. D. WHITMER: A thicker bottom undoubtedly helps considerably. With a denser sagger there will be a tendency for the bottoms to sag down. A thicker bottom will help to offset this also.

E. H. FRITZ: We found that very definitely. It helps very much on the saggers that have a rather heavy load.

E. SCHRAMM: We have had an interesting experience along the line of sagger clay preparation. At our old plant the clay is prepared in soak pits; the former practice was to flood the pits, drawing off the excess water after a period of standing. On introducing more ground clay into the mix, this method did not work as the flow of water was impeded; accordingly, we cut down the depth of the layers, put a water meter on the water line, and sprinkled a measured quantity of water on each layer, using no excess. In this way we succeeded very well in handling mixes of that type in the old fashioned soak-pit.

The question of grading of grog is a very interesting one and I believe the correct principles were worked out ten years ago by Kirkpatrick.[1] For a practical solution we must strike a point of balance between the high thermal resistance of coarse bodies and the high mechanical strength of fine; this point of balance will vary with differences in plant conditions but I think we are most likely to err on the side of over-coarseness.

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[1] *Trans. Amer. Ceram. Soc.*, 19, 268 (1917).

We prepare grog in 2 different ways, by dry pan and screen and by hammer mill. We attempt to get similar distribution of sizes by the two methods. Typical analyses of the grog are as follows:

	Per cent rejections on standard screen number								
	4	8	14	28	48	65	100	200	Through 200
Dry pan	0	37.2	33.0	16.2	3.5	1.5	2.7	5.9	none
Hammer mill	0	29.0	27.5	18.9	11.9	3.4	2.3	2.9	4.

W. K. McAFEE: There is a point in connection with the sanitary ware business, and also the general ware business that has not been mentioned, and that is the question of spalling. In connection with the saggers Mr. Whitmer spoke of, do they show a tendency to spall? We get twenty to thirty firings on our saggers, and we have somewhat the same trucking problem that Mr. Whitmer speaks of. The limit to the life of our saggers is the amount of spalling a sagger undergoes, rather than actual breakage of the saggers; that is, we generally throw away our saggers while they are still usable from the mechanical point of view.

This question of spalling seems in some way to be tied up with the question of the size of grog. We have not made any real investigation on this question. We have been unable to make a sagger of high mechanical strength that is free from spalling. We can get one or the other property but we have not been able to get both.

J. D. WHITMER: Our observations have been made in connection with bisque firing where the factor of kiln dirt does not enter seriously. However, I am satisfied that the denser sagger we are now using will reduce kiln dirt losses in the glost fire because our previously used sagger was entirely too open.

The size of grog is undoubtedly an important factor in spalling. However, we are now using the same body for bisque and glost with equally satisfactory results when compared to our experience with the old body.

E. H. FRITZ: This matter of spalling is also of importance with us because it is very essential that our apparatus porcelain, which is used on transformers and circuit breakers, is very free of blemishes of any kind for the standards in regard to appearance of apparatus porcelains have been raised in the last five years. We have also observed that a tighter sagger will give less spalling. We had more of it when we had a more open sagger body.

The method of making saggers has some bearing on this problem also. Our saggers are all pressed. Pressing gives a very clean cut edge. This eliminates spalling which might be encountered when the saggers are not well-filled out or well-pressed.

W. H. VAUGHAN: We conducted a few simple experiments using the same amount of grog and the same amount of plastic material. Starting with grog that just passed three-eighths and was retained on 4-mesh, we made up a series of six mixes, and subjected them to various tests, such as porosity, green and fired modulus of rupture, quenching, etc. In these particular tests we weighed eight standard-sized pieces of each before and after quenching ten and twenty times. The flaking decreased very rapidly with decrease in the size of the grog. However, when we began to get mixes with grog finer than 8-mesh, the spalling resistance gradually decreased; that is, the bodies containing the grog which passes through 40-mesh broke in two very quickly.

In this series the bodies containing the finest grog, (through 40-mesh only), stood an average of eight quenchings. However, the eight-mesh grog seemed superior. We considered a body as failing when a quarter of the volume of the body had broken off.

Quenching or spalling and flaking, are not analogous phenomena; they are opposite, as far as my experience indicates. There is a certain point in the size of grog, which, in our experiments was eight-mesh, which gave the maximum resistance to quenching in the true sense where this means spontaneous cracking-off of a fourth or more of the piece volume. At this grog size also we found high flaking resistance.

G. SIMCOE: Mr. Whitmer, do you think yours a fair test? Putting through a clay in the manner described would throw it out because of the result of the test. The sagger body is a mixture of several clays, and the proper combination of two or more clays made into a bar leaving out the grog, and tested by your method might give a result that would be all right.

J. D. WHITMER: Our experience indicates that the behavior of the clay tested individually is reflected in the sagger-mix. That may not be true of all clays, however.

G. SIMCOE: That was just my point, a proper combination. There is a complementary clay, we might say, that goes with another clay, that might give the results to be desired.

A MEMBER: Has an effort been made to study the effect of the rate of cooling or has anything been done to correlate the relations between service conditions in this respect and these spalling tests?

E. H. FRITZ: All of our own data are based on our standard cooling procedure, and we have never covered any study of the effect of changes in the cooling cycles on the saggers.

C. W. PARMELEE: An acquaintance wanted to get out the largest amount of ware possible and therefore cooled his kilns very quickly

and as a result he lost his saggers. The rate of cooling in kilns is not alike in all cases but it would be serviceable if some attempt were made to determine what relation there is between the rate of cooling and loss, and also the rate of loss as reflected in the spalling tests which are, of course, accelerated tests.

E. H. FRITZ: It is also possible that two bodies which give different results with a given cooling cycle, would, with a different cooling cycle, be reversed in their performance.

A MEMBER: The life of the sagger depends on what temperature it is fired to in comparison to what temperature it is going to be subjected to later, does it not?

E. H. FRITZ: We have fired some saggers slightly higher the first time than the temperature at which they were regularly used later and we cannot find that there is any advantage in it. In some cases we actually obtained adverse results by firing them too high the first time. Our standard procedure is to fire them at the extreme top of the kiln, where the temperature is not quite as high as it is down lower in the kiln. Thus we fire slightly lower the first time than we do later on.

J. B. SHAW: With reference to those clays which have had a rather peculiar property of increasing in modulus of rupture with successive firings what are the other characteristics of those clays, if any, which would distinguish them from other fired clays, which do not show that property?

J. D. WHITMER: That is a question I cannot answer. We are merely interested in securing a better sagger. Referring again to Mr. Simcoe's contention, I want to say that for four or five years we have tried nearly every clay that any salesman recommended for making good saggers, but that we never got anywhere until we started this line of investigation.

A MEMBER: Is there any advantage in the preparation of the sagger mix in the wet pan? I refer to Mr. Bleininger because I knew a wet pan was used in one of the plants of his Company.

A. V. BLEININGER: I covered the subject last year.[1] The record of that plant in regard to saggers has not been a brilliant one at all, except in the last year. The life of the saggers did not seem to have been increased by the wet pan treatment, but the amount of kiln dirt let loose by the saggers appeared to be less in that plant. Now, whether or not it is due to the wet pan treatment, I do not know.

E. H. FRITZ: Have you noticed any effects during the past year, insofar as longer life is concerned?

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[1] See Sagger Symposium, *Bull. Amer. Ceram. Soc.*, **5** [12], 445–59(1926).

A. V. BLEININGER: The life has been longer, and the kiln dirt has not increased. In this particular plant the drying space has been restricted, and the drying facilities were rather poor, so about a year ago the space was increased by about 30% and consequently the time and the thoroughness of the drying was likewise improved. There is no question but that the increased life was due to the better drying conditions which had been provided.

E. H. FRITZ: Our experience is similar to that. We can ruin our saggers if we dry them improperly. That is very easily done.

Does anyone have any data on the effect of renewing the grog?

J. D. WHITMER: We have had a little experience along that line which may be of interest.

Using our old sagger-mix, we introduced grog made from old fire brick. This seemed to add considerably to the life of the sagger. These saggers were saved and ground up for grog, which was used with the same clays as in the original batch. This time the life was materially less than that of the first batch. This procedure was followed out two more times, and in every case the life of the batch was lessened, so we concluded, that there must be something radically wrong with our mix.

However, the grog from our new mix is now being used and so far no bad effects have been noticed. I believe, however, that an occasional renewing of the grog is beneficial.

E. H. FRITZ: Does anyone have any additional data to present on cast saggers? Mr. McAfee, do you cast saggers?

W. K. MCAFEE: We have had to give up cast saggers at our Cambridge plant due to lack of floor space in which to make them. From a refractory point of view they were excellent. We did have some trouble due apparently to mechanical injury in trucking. Our New Castle plant has been using them for years with excellent results. In their case they do not have to truck the saggers. The principal advantage in cast saggers according to our experience lies in their "slick" surface which practically eliminates sagger dirt.

G. KLEIN: We make a few cast saggers. What Mr. McAfee says is true in a certain way, but if anybody is interested in going into it I would be glad to talk to them, and work out some arrangement whereby they can see in their own plant what cast saggers will do. We make them commercially.

E. H. FRITZ: What is the principal advantage that you claim for the cast sagger?

G. KLEIN: We think it gives a cleaner surface, cleaner ware, and in some places it seems to give a much longer life, but it is a very difficult problem where you have to stack them up, fifteen, eighteen, twenty

high, in a kiln. The breakage is high, and although the saggers are stronger, they are more expensive. In the tunnel kilns pressed saggers are of advantage and seem to work out quite satisfactorily.

W. H. VAUGHAN: The experiment which I mentioned is only a laboratory experiment. It is going into the plant now, however. In one series of mixes of various specifications and grog contents, all of the same size, we found the fired modulus of rupture varying from about 900 pounds per square inch up to about 1800 pounds per square inch. In quenching test pieces about 2 by 2½ by 3 inches we found that those mixes showing high modulus of rupture developed major cracks; that is, the body cracked squarely in two. The flaking was low. Whereas, in those with the low modulus of rupture, the major cracks of quenching were minimized, and the flaking was rather high.

None of the commercial plant mixes which we have tested, amounting to about six from various plants, have run a fired modulus of rupture over 800 pounds per square inch. However, all of these mixes, which principally contain grog of one-quarter mesh or larger, gave high flaking results, something like ten times the bodies containing finer grog; that is, about 8-mesh.

E. H. FRITZ: Do you intend to publish this data?

W. H. VAUGHAN: It will be published later on. There is going to be a correlation between laboratory results in this case and plant firing, as we are going into plants with some of these mixes.

C. E. DOLL: The Colonial sagger clay is very beneficial, as a rule, in sagger mixes. All of the so-called Colonial clays come from the same general locality, but there is a very marked difference in the way they are selected and prepared. Anyone who contemplates adopting Colonial clay should be very careful to get the clay from the best source, and not use Colonial clay unless they have actually made sure that they are getting the best.

J. B. SHAW: With reference to this Colonial clay which has gained an enviable reputation as a sagger clay, it is unfortunate that a number of clays from the immediate vicinity from which this clay is obtained have been marketed as "Colonial" clay and recommended for use in making saggers. There are a great many pockets of clay in that vicinity but only a few of them have thus far been found to possess the excellent qualities for sagger bodies that are characteristic of this Colonial clay.

Unfortunately the quantity of this clay available seems to be quite limited and my previous question was intended to bring out the characteristic properties of these clays so that other clays might be substituted for those which become exhausted as the Colonial clay will inevitably be in a few years.

FIRING "HOGGED FUEL" IN A CONTINUOUS CHAMBER BRICK KILN[1]

By O. K. Edwards

It is probably well known to all clay workers in the Pacific Northwest, that the term "hogged fuel" refers to ground slab wood and sawmill waste, and is quite similar to a mixture of ordinary sawdust and planer shavings.

The burning of "hogged fuel," like all other fuels, is a matter of turning the solid fuel into gas and the controlled burning of the produced gas. This is largely a matter of furnace construction and air control, as it is with all other solid fuels such as coal or wood.

It is possible to consume hogged fuel in almost any kind of a solid fuel furnace, but there is a very great difference between burning or consuming the fuel and the successful burning of brick with hogged fuel. The real problem is not the simple burning of the fuel but the control of the combustion. Although the laws governing the burning of hogged fuel are the same as those governing the burning of other solid fuels, yet the physical nature of this fuel is such as to make the problem quite different.

Hogged fuel is bulky and relatively light in weight, carries a large percentage of water and packs into a dense mass. The last of these characteristics, that of the fuel laying close together, makes it difficult to pass the air through the fuel in a manner similar to that done in burning wood or coal. This makes it necessary to have a furnace constructed upon the principle of the gas producer in which the fuel is heated to a sufficient degree to drive off the gas and carry, or later add, the necessary air for combustion of the gas. This is a more extended process than that of burning wood or coal. This type of furnace is well illustrated in the Dutch oven so commonly used under steam boilers where the grates and fuel chambers are placed in front of the boiler in which the gas is generated and is burned farther back under the boiler.

In undertaking to fire brick with hogged fuel in our downdraft continuous chamber kiln we considered the best practice in use, and endeavored to carry out the same principles in our kilns. This we found to be very difficult as it requires a large amount of room for the gas producing chamber. The fuel also must not be allowed to come in contact with the ware. Before undertaking this revolutionary method of firing we satisfied ourselves that our kiln was so constructed as to be

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[1] This paper was presented before a meeting of the Pacific Northwest Clayworkers' Association and Local Section of the American Ceramic Society. Received April 5, 1927.

adaptable to the best process of hogged fuel burning. We found in actual practice that the construction of a furnace within the kiln which would produce the desired results was more than a theoretical adaptation of the principles so well understood in the ordinary burning of hogged fuel. We found the experiment very expensive on account of damaged ware and the cost of having to rebuild our bagwalls and furnaces three times before we secured satisfactory results.

Our continuous chamber kiln, is constructed quite similarly to a series of ordinary small rectangular kilns, except that they are only about twelve feet wide and have a bagwall along only one side of the kiln, as the firing is all done from one side. Behind this bagwall and about two feet from the top is a fire grate, or fire table with openings about three inches wide and spaced about eighteen inches between the openings. The fuel fed from the top of the kiln drops upon these tables, small portions passing through the openings and burning at the bottoms of the bagwalls where the hot air comes through from the preceding chamber. This keeps the firebrick tables heated to a high degree causing the hogged fuel to ignite and throw off the gases very rapidly. These combustion tables are far enough from the burning brick to permit the gases to burn before striking the brick. With this type of combustion chamber the moisture in the fuel is broken up and made harmless.

Hogged fuel is bulky and relatively light so that it is necessary to have an extensive set of conveyers for handling the fuel with the minimum of hand labor. Unless this is done all the economy of the first cost of the fuel will be lost in the excessive cost of handling. It is also necessary to have a large storage so arranged that a constant supply can be maintained without appreciable additional cost in handling.

Our fuel is handled in open top railway cars with sides about ten feet high and with doors along either side for unloading. Along the side and just below the level of the car floors, for nearly the length of three cars, is a conveyer that carries the fuel to a second conveyer which lifts it to a storage pile about thirty feet in height or delivers it direct to a third conveyer. This carries the fuel to the top of the kiln shed and there delivers it to the kiln conveyer, or to the boiler conveyer, or to both as the need may be. The kiln conveyer runs along the center line and the full length of the kiln. This conveyer is some twenty feet above the top of the kiln. Immediately under this conveyer, running the full length of the kiln, is a storage bin, the bottom of which, is some eight feet above the top of the kiln. By opening a gate in the bottom of the conveyer the fuel is dropped in that portion of the bin opposite the chambers on fire. The fuel is then drawn from the bottom of the bin into a small car that runs out over the burning chamber and along the fire holes, where the fireman draws such fuel as he may re-

quire. The operation is all handled by one man on the kiln and another at the fuel pile or on the car. Three men on each shift easily handle the entire fuel system of the plant: that is, one man at the car or storage pile, one on the kiln and one at the steam boilers, which supplies steam for the driers as well as for the power plant.

We have found hogged fuel satisfactory for firing brick only when the furnace is specially constructed for this particular fuel, and is an economic fuel only when the equipment for the handling and storage is such as to reduce the labor of handling to the minimum.

WILLAMINA CLAY PRODUCTS COMPANY
WILLAMINA, OREGON

CLAY WASHING[1]

BY J. M. HARBY

In March, 1925, when I first saw the kind of kaolin I had promised to refine for the Washington Brick, Lime and Sewer Pipe Company of Spokane, I was not nearly as enthusiastic over the prospect as I have since had good reason to feel. Having gained my clay washing experience in Georgia and South Carolina, where the deposits are sedimentary and, in most cases 99% pure, you can imagine how I felt on seeing a residual deposit running about 35% kaolin and the other 65% composed of fine silica, quartz, and mica. I knew that the task would be no easy one and that there would have to be special apparatus, not then used in washing plants, designed to handle it in an economical manner.

These deposits of kaolin are located at Freeman, in Spokane County, Washington, in the Mica Peak district, about eighteen miles southeast of Spokane. The Company owned a common brick plant there, which was being dismantled, but which still had its power plant intact. It was proposed to convert it into a clay-washing plant.

We proceeded along accepted lines for a flotation process.

I shall describe this in detail inasmuch as it is, as far as I know, the pioneer kaolin washing plant of the entire west, and also because there are two features of it that are entirely different from anything used by other washing plants.

The clay, after being mined and placed on the feeding floor, is passed through a disintegrater or set of crushing rolls, which reduce the lumps to about small marble size. From the rolls it drops into a blunger, or agitator tank, into which is running a stream of water controlled by a valve. This blunger is a rectangular tank four feet

[1] See footnote 1, page 195

wide, six feet long, and four feet deep. Two horizontal belt-driven shafts, holding the beater arms, extend through the sides of the blunger. These vertically rotating arms agitate the mixture and wash the clay free of silica, quartz, and mica. The level of water is held near the top of the blunger by a high overflow opening at the discharge end. The flow is regulated by the amount of clay and water admitted to the blunger.

Here was our first difficulty. Most blungers used for clay washing, revolve about 90 r. p. m. This speed was found to be ample as far as putting the clay in suspension, but all of the heavy particles of quartz, mica, and small pebbles accumulated in the blunger and required removal so often that it was not practical to operate it in this fashion. Several methods of ridding the blunger of this accumulation during operation were tried unsuccessfully until higher speeds were used. After raising the speed of revolution to 140 r. p. m. with fair results, the speed of 185 r. p. m. was finally adopted, and this agitated the mixture so violently that the heaviest pebbles passed out the overflow in a very successful manner.

After the material was thoroughly blunged, the next problem was to remove the foreign matter from the clay water. This is usually done by settling troughs, long channels through which the blunged material flows at just enough speed to carry along the clay held in suspension, but in which the fine sand and mica will slowly settle to be removed finally by shovels. This works well where the percentage of foreign substance is low, as the troughs do not require much cleaning, but with our material containing about 65% foreign substance, the troughs filled so rapidly that we could not clean them out fast enough.

We tried a revolving screen and sand traps of various kinds but without success. The screen would separate the coarse material but would leave the fine silica and mica, which soon filled our troughs to overflowing. We could trap the sand but could not get it away from the traps in any practical manner, until we invented the self-cleaning trap or sand separator. This catches the overflow from the blunger, and consists of a four-foot wide vessel with one vertical end and a sloping end, inclined about 30° from the horizontal. This slope forms the bottom as well as the end.

As the blunged material flowed into this, the heavy particles settled to the bottom and the clay, carrying some of the fine sand and particles of mica, would flow out through the opening in the side wall up above the bottom. Two-inch by two-inch angle bars operated on link chains and sprocket wheels, at a slow speed, to prevent stirring the settlings, dragged the latter up the sloping bottom until they dropped outside.

This took out so much of the foreign substances that the troughs could easily be kept cleaned of further settlings.

It was found, however, that quite a little clay was carried over with the heavier material removed, so a second and smaller blunger was installed, with a duplicate sand separator behind it, and all the clay recovered. The clean washed sand dropped on an inclined belt conveyer and was piled well away from the plant.

The settling troughs are kept cleaned of settlings by a man who shovels them on to another inclined belt conveyer that takes them away.

Our dehydration is effected in the usual way by settling in tanks and draining off the excess water. As the clay is slow in settling we use an acid flocculent to hasten it. We then pump the slip into shallow tanks to air dry. We are now working on a direct heat mechanical drier to handle our product that promises to give economical results and obviate the use of filter presses.

In designing the plant there were two points constantly held in mind, (1) continuous rather than intermittent or batch operation of all processes, and (2) economy of man power. The plant handles forty-five cubic yards of raw material per eight-hour day, fed continuously with but two hands engaged in the washing processes. They consist of a feeder of the raw material, and a man to clean out the settling troughs.

As you know kaolin is highly refractory, but there is another very important factor which is not always present to a high degree, namely, plasticity.

The clay from the Freeman pit, which we are refining, has extremely high plasticity, and the refractory products made of the pure clay, have been tested by several of the best recognized authorities with very flattering results. The cone fusion is between 34 and 35. At cone 6, samples show a crushing strength of 1485 pounds per square inch, and at cone 16, 3105 pounds per square inch.

WASHINGTON BRICK, LIME, AND SEWER PIPE CO.
FREEMAN, WASHINGTON

FIREBRICK PROBLEMS[1]

BY TOM HALL

Joel, Idaho Fire Clay Pit

At the present time, we operate a fireclay pit at Joel, Idaho, and mine the clay to a depth of sixty feet. We find that the clay from the deeper portions is more plastic than that from near the surface. The first

[1] See footnote 1, p. 195.

twenty feet below the surface is coarse fire clay with a high quartz content and this without the addition of plastic fire clay is very hard to handle. Even after firing the brick to cone 15 they are very soft and fragile for shipping. However, by the 50% addition of a high-grade, plastic fire clay which we have recently purchased, we get a No. 1 fire brick that is suitable for most purposes.

The fire clay from the lower part of our pit can be used for the manufacture of fire brick and special shapes without the use of another clay, for this material is finer and has a lower silica and higher alumina content. We have bored to a depth of 100 feet and have not run out of clay so the deposit must be very deep.

Manganese Stained Fire Clay

In a neighboring pit about forty feet deep, the fire clay is impregnated with manganese and while the brick made from this material have been tested to cone 33 and are very good for furnace work, yet the dark color caused by the manganese kills their sale. Some of these brick have been used in high pressure boilers for several years in constant service and are still going strong. However, the color is against this class of brick for retail trade. We should like to have comments and suggestions on this manganese stain trouble.

Water Glass and Common Salt Additions to Fire Clay

We have found that water glass will improve the working conditions of a weakly plastic clay, especially where there is considerable hand molding. If the water glass proves too expensive, common salt could be used with the same results, but great care should be taken in the mixing with clays for if too much is used, the fire brick will be ruined. One illustration noted by the writer on the fired brick, showed large blisters the size of a quarter all over the surface of the brick, extending to a depth of one-quarter of an inch. This of course was carelessness in mixing and proportioning, for if salt is used in the right proportions with lean fire clays it will work wonders in the bonding of the brick.

The hardest problem that the manufacturer of fire brick is up against is to get a fire brick that will meet all purposes and resist the attack of all the kinds of fuel used in the West. It is well known that the coal measures contain springs strongly impregnated with common salt and the latter is frequently found also in the coal. So if a certain fire brick was used in the construction of a coke oven and this particular fire brick was not adapted for the construction of coke ovens, we would have trouble. The salt decomposes at the high temperatures into sodium and chlorine. The sodium combines with the silica and alumina of the brick to form a liquid slag, which drops off. The chlorine gives the

brick a spongy appearance as mentioned above where too much salt was used in the fire brick mixture. Inspections of bee hive coke ovens have shown an almost complete destruction of the fire brick from the salt vapors.

The above is only one of a great number of problems which the firebrick manufacturer is up against; some are being worked out successfully and many others are in progress of solution.

Moscow Fire Brick and Clay Products Company
Moscow, Idaho

CLAY MINING[1]

By J. G. Adderson

The material mined is hard Tertiary shale used in the manufacture of paving and building brick and tile. Over 100 feet of glacial overburden is removed by hydraulic methods before the shale is mined.

The tunnel method in use at the Renton plant, consists of a series of tunnels, spaced 20 feet apart, driven into the solid shale for a distance of 10 feet, with about 50 feet of tunnel or ten sets of bracing extending back from the bank of shale. This section of tunnel carries the shale shot down from the bank which averages 150 feet high.

A battery shot consisting of four to six holes, two inches in diameter and 16 feet deeper, loaded with about 40 to 60 sticks of dynamite to the hole brings down from 500 to 2000 tons of clay. With this tonnage falling from such a height it can be readily understood why a strong system of timbering is used.

In many shots some of the broken pieces of shale are so large that they have to be drilled and blasted to reduce them to a proper size for the crusher. The impact of pieces of this size is very great and only the strongest timbering will withstand such treatment.

By lifting the loose lagging on top of each tunnel, the clay or shale falls through the stringers and hoppers into the car beneath. The loaded cars run by gravity down to the automatic rotary car dump. The large pieces which pass through a crusher and the fines which have dropped through a grizzly are delivered by a feeder to a belt conveyer which carries them to bunkers in the factory.

One of the chief advantages of a system of this kind is the excellent drainage afforded the pile of clay lying on top of these tunnels. It is a matter of record, that there has never been a time during the wet winter months when we could not grind clay directly from the bank, since these tunnels were installed.

[1] See footnote 1, p. 195.

A set consists of about 1380 board feet with the necessary nails, lag screws, and iron. This, with the labor of installation may seem expensive, but when properly placed is good for many years of service, for as the bank recedes, the outermost set can be taken down and placed in heading underground. In a pit containing different clays, an even mixture can be maintained by locating the tunnels under the different classes of materials to be used.

DENNY RENTON CLAY AND COAL COMPANY
RENTON, WASHINGTON

MINING SHALE FOR SEWER PIPE[1]

BY W. E. LEMLEY

In describing the method of mining Taylor shale, we liken it to the system used on Treadwell Island for getting out the low grade gold ore: the "glory hole" system.

The shale veins mined are 260 feet in thickness. The underlying portion is a massive seam about eighty feet thick. Overlying this is a seam of very hard and rocklike shale containing millions of clam shells, and is termed by us as the "clam-shell vein." Overlying the clam-shell vein is a vein of about ninety feet in thickness of a stratified shale, a small layer, perhaps one inch or so of fine shale and perhaps one-half inch or so of sandy shale. Above this is a vein of fault rock, which is an intrusive dyke that has displaced a coal seam of eight to ten feet in thickness. From there on out to the overlying sandstone is a vein of seventy feet of massive shale.

There is much evidence of marine formation in these shale seams. They are located in what is known as the Taylor syncline, being pitched at an angle of 78°. Prospecting has shown that these veins of shale hold good throughout the entire run of the syncline, and are very uniform in quality.

The point at which this shale is mined is about 100 feet above the storage tipples, and about 1100 feet horizontal distance. The method used is to drive a tunnel crosscutting the veins. From this crosscut tunnel chutes are driven to the surface, about 185 feet from the track level to the surface. The first part of the chute is driven at an angle from the gangway of about 40°. It is driven about 8 feet wide, 6 feet high, and is all timbered with five-piece sets, the center of the sets being fitted with a post. In this is installed a chute 4 feet wide and 24 feet in length, with a sheet-iron bottom and ordinary plank sides. The lower end of this chute is fitted with a gate for trapping the clay

[1] See footnote 1, p. 195.

into the cars, and the upper end is fitted with a heavy timber battery to withstand the shocks of the large lumps of shale pounding against them. Openings are left at the battery about thirty inches high and four feet wide.

The crosscut tunnel, for the main part, is about the size of an ordinary coal gangway, having 8 feet collars, 10 by 12 inches, 10 by 10 inch legs, 6 feet 4 inches in the clear at the top, and 9 feet in the clear at the bottom, with 6 feet 6 inch clearance above the rails. This is all lagged in top and sides in order to keep the weathered shale from falling down onto the track. At points where chutes are driven the collar is increased to 10 feet to make room for lever operating gate.

We have what we consider a very novel gate for handling this class of material. The side pieces of the chute extend into the gangway, longer than the bottom plank. A slot is left in the bottom and a table is fitted to the extending portion of the side planks. This leaves a slot for the gate to work through from the bottom up. A three-inch ordinary iron pipe is fastened to the collars and this forms a fulcrum for an "A" frame which serves as a lever for operating the gate. The underneath portion of the gate is fitted with an iron which extends past the chute sides. To the ends of the "A" frame, and connecting with this extended piece of iron on the bottom of the gate, are links made from ordinary rod iron. By lifting up on the "A" frame the gate is pushed downward which lets the shale roll into the car. As soon as the car is full a downward pull of the "A" frame brings the gate up through the bottom of the chute and closes off the flow of clay. Several methods of controlling the shale in the chute have been tried and finally this gate, a very neat working mechanism, was devised.

After the chute and gate are installed we start for the surface with our chute. This is driven to the surface by a miner in much the same way as an ordinary coal chute, or as any other chute would be driven. It is driven about five feet square and on an angle at which a man can work nicely, 50–55°. The only timber installed in the chute during the operation of driving is just enough for a man to set his drills and stand on.

There are generally five holes shot at each round, one cutting shot in the center about 3 feet 6 inches deep, with four corner shots about 6 feet deep. All drilling during driving operations is done with a Waugh Stopper, using cruciform steel and operated with 100 pounds air pressure. We use 40% straight nitroglycerine powder.

As soon as the chute is through to the surface we put a row of holes down through the chute and ream it out sufficiently so that large lumps of shale may not stick and we are sure everything is coming to the battery.

The operation then is simply to cave the chute. Most of the drilling is done during this caving process with an ordinary churn drill, or with a Watcheer twist drill. We generally drill our holes for caving about 16 to 18 feet deep, spring them with about two sticks of powder and put in 90 to 100 sticks of $\frac{7}{8}$ inch powder. This brings down an immense quantity of shale. Some of the lumps are quite large and require some bull-dozing and some shooting is necessary at the battery in order to get the lumps through the chute. We find this a very cheap and efficient method of getting shale mined. Where the shale is overlain with gravel, we simply clean out the chute, throw the gravel into the chute and take it out to the gravel dump in the same manner as we handle the shale.

For haulage on the inside of the clay mine we use a five-ton Westinghouse Electric Locomotive. From the mouth of the mine to the storage piles it is let down by gravity. Six men will mine and deliver on the storage piles about 200 tons of clay in eight hours.

We also mine in Taylor a white clay, but this is only about a 24-foot vein. This mining is done by the chute and pillar system, much the same as coal is mined.

The mining of our fire clays at Sumas is done by the breast system, and instead of blocking out the clays as it is done in coal mining, either the square block or angle block is used. A chute is driven off the gangway narrow for a distance of 12 to 15 feet, and then the chute is widened to whatever the hanging wall will permit. In the case of our mining at Sumas the breasts are driven about 24 feet wide, leaving about five or six feet to sustain hanging wall. The pitch of the veins at that place is about 40°.

GLADDING MCBEAN AND COMPANY
TAYLOR, WASHINGTON

NOTES ON CLAY MINING[1]

BY JOSEPH DANIELS

Clay and shale mining bear a relationship to the general methods employed in mining ores and coal but have certain individuality based on the nature of the raw material, topographic conditions at the deposits, and the seasonal problems involving moisture, climate, storage, and the like. Open pit, underground, and combined systems such as glory holes, and milling methods are in common use. The salient features of some of these have been presented in the preceding discussions but it is desirable to point out certain lines of possible progress.

All clays and many shales, from their plastic nature cannot be broken down by direct caving into masses similar to coal or ores for easy hand-

[1] See footnote 1, p. 195.

ling and transportation. A careful study of the placing of blast holes, more intelligent and efficient use of explosives, and the selection of light, portable, simple drilling or boring equipment such as that represented by the compressed air, auger-rotator types of hand-held drills are suggested as the first step toward the problem of cheaper mining. Related to the foregoing is the question of support of workings. Systematic planning of operations, rather than the haphazard, irregular methods now in vogue, particularly if coördinated with good mining methods, will simplify the matter of support, particularly in timbering.

Clays, like coals, must be handled at a minimum of cost. Simplification of excavation and transportation methods is necessary to overcome the hardships of intermittent operation, casual labor problems, and high capital expenditures for machinery. In this connection, the matter of mechanical digging and loading machinery, now being developed and utilized in many of the coal and metal mines, is suggested to the clayworker as a means of possible advance in the technique of digging and loading. Transportation systems employing portable conveyers may supplement these devices in place of the ordinary cars or be used in conjunction with cars.

These machines are not universal in their scope or application, but each type must be carefully analyzed to determine its applicability to the problem in hand. The American Mining Congress is now beginning an investigation of mechanical loading and the results of its studies, made under the direction of Glenn B. Southward, will undoubtedly be a distinct contribution to the technique of mining. The clay miner should familiarize himself with the application of these devices to his special field.

The seasonal problem involving the mining, handling, and transportation of shales and similar deposits can perhaps be met by a combined open and closed mining method, using the first in the summer months and the latter in the wet and colder months. Suitable drainage facilities are provided by tunnels or drifts which also serve as places to load and transport the mined clay.

In mining glacial clays which become wet and sticky during the rainy season ordinary underground methods will not materially assist in drainage or in ease of mining. Here open methods are unquestionably the simplest, but it may be desirable to store the clays mined during the drier periods in sheds or under some form of suitable cover.

The aim in this brief discussion has been to point out certain lines of attack of possible economic value to the clay workers, these lines representing the experience of the workers in related fields of mining activity.

College of Mines
University of Washington

ACTIVITIES OF THE SOCIETY

ITINERARY PROPOSED FOR THE AMERICAN CERAMIC SOCIETY EUROPEAN TOUR

May 19 to July 5 inclusive

Foreword

Please note that the following tour has been built around European ceramic centers such as:

Stoke-on-Trent and the "Potteries" in England
Delft in Holland
Meissen in Germany
Prague in Czechoslovakia
Paris in France

Membership in the ceramists' tour should be inclusive, hence it is planned to include:

1. Comfortable cabin accommodations on Cunard Liners both to and from Europe with all expenses paid except the usual tips aboard ship.
2. All gratuities to hotel and train servants in Europe with the exception of tips to hotel servants in the British Isles. English hotels request that guests tip individually and not en masse.
3. All taxes levied by cities and countries through which members may pass.
4. Transfer of members' baggage from railroad station to hotel and vice versa.
5. Sightseeing by automobile or other vehicles, including the services of local guides when found necessary.
6. All meals at all times during the tour.
7. Comfortable accommodations in first class hotels throughout.
8. Comfortable reserved accommodations on all railroad trains and local steamships, using (as is customary) first class sleeping compartments and first class cars when such trains are used, first class staterooms on Channel Crossing, second class on the European Continent and third in England for the short journeys.

Itinerary

Montreal–Saturday, May 19

Here the members congregate for a ceramic breakfast, preparatory to taking a delightful trip up the St. Lawrence River to the open sea, and thence across the Atlantic.

At Sea–May 20 to 26

Aboard the luxurious Cunard liner many a happy hour will be spent on deck, in the various lounges or in the comfortable smoking room. Band concerts, dancing, athletics, bridge, all serve to make the crossing a true vacation. Informal meetings of ceramists will also be arranged.

Glasgow–May 27

Today the members reach Glasgow and are met by the Reception Committee, and later on are esconced in a comfortable Scottish hotel for the first night ashore for over a week.

The Trossachs–May 28

Before proceeding through Scotland and England a day is spent in one of the most beautiful scenic spots in the world; by rail, motor coach, Norse coach, and lake steamer Loch Katrine, Loch Lomond, Sterling Castle are visited.

Edinburgh–May 29

For those who desire to continue their sight-seeing provisions will be made for a coach trip to Sir Walter Scott's country and Melrose Abbey. Others may wish to make the acquaintance of Edinburgh manufacturers in similar lines of business. By train from Edinburgh the party will proceed overnight to the center of England.

Manchester, Sheffield, Stoke-on-Trent, and Worcester–May 30 to June 2

Glassware, refractories, brick, pottery, and enamel plants lie within easy reach of this beehive of activity, but of most interest, this is the home of the Ceramic Society and of the Society of Glass Technology. J. W. Mellor and W. E. S. Turner and their associates, with many of whom we are personally acquainted, are planning that each member of the ceramic tour party shall visit the plants in which each is interested.

Returning to Birmingham provisions are made for the tour of Shakespeare's country and Oxford enroute to London. Before noon the quaint old English village of Stratford-on-Avon is reached. The old house in which the poet was born is visited; Ann Hathaway's cottage, where Shakespeare wooed the girl who afterwards became his wife is the next stop. The countryside which is so beautiful that it beggars description will seem like a day in fairyland.

From Stratford-on-Avon the party will travel *via* Oxford, famous university city, to London where a royal welcome will await from British compatriots.

London–June 3 to 6

Comfortably settled in first-class hotel accommodations in the heart of London members will have practically a full week for further ceramic meetings and entertainment as well as for the very necessary sightseeing which every American enjoys. Visits will be made to The Tower, Windsor Castle, Stoke Poges, and other vitally interesting places.

For those who desire to visit the famous clay and Cornwall stone quarries, special trips will be arranged.

Late Wednesday evening a start will be made for the Hook of Holland which will be reached by boat from Harwick.

Delft–June 7

From the Hook of Holland, which is reached in time for breakfast the members will proceed from Rotterdam to Delft, a forty-minute train ride. One day is spent with our Dutch confrères and much of interest will be found on the banks of the rivers Schie and Rhine. Inspection of plants and many interesting meetings are arranged. (Those who desire to proceed direct to Berlin may do so and eliminate the day in Delft thus gaining one more day in the German capitol.)

Amsterdam–June 8

Comprehensive sightseeing will be indulged in while in the "Diamond City" and plenty of time spent in resting or for independent action. Late in the evening a sleeping-car train will be boarded for Berlin as this is rather a tiresome journey and may well be taken at night.

Berlin–June 9 to 12

Arriving early in the morning there will be no regular program until after lunch when a formal business reception will be held.

H. Harkort of the German Ceramic Society and H. Maurach of the German Society of Glass Technology, are planning with their associates several optional plant visits for those whose special interests are brick, refractories, pottery, terra cotta, glass, or glass enamel.

Three days will be devoted to the German industries but there will be plenty of entertainment for those who wish to spend part of the time on vacation. Berlin to Dresden is but a five-hour run and the ceramists will arrive there late in the evening. (For those who desire to delete Dresden from their itinerary, arrangements will be made for an additional two days' stay in Berlin, or for them to proceed directly to Prague for two days' additional time thereto.)

Dresden and Meissen–June 13 to 14

Two days will be spent in the Saxon capitol one of which will be devoted to visits to leading manufacturing plants. Dresden is altogether delightful and will appeal with its antiquities to everyone who likes old world charm.

Prague–June 15 to 17

Beautiful Bohemia offers much of extreme interest to the ceramist, hence a full three-day stay has been arranged using Prague as a base.

R. Barta, Secretary of the Czechoslovakian Ceramic Society reports that members of that Society are making ready for whatever special plant trips the tour members may desire.

Very few spots in Europe offer such a variety of interesting buildings, castles, cathedrals, churches, monasteries, palaces, and parks as Prague. A very full program is being worked out as this is considered one of the "high spots" of the tour.

Nuremberg–June 18 to 19

Leaving Prague around noon the party will reach Nuremberg in time for late dinner after an interesting run across interesting country. The following day will be given over to sightseeing or rest, according to individual desires.

Munich–June 20

But a few hours away lies Munich, the next port of call, well worth a day's stop over. Competent guides will see that nothing really worth while is overlooked.

Lucerne–June 21 to 22

By rail and lake steamer the party will reach Lucerne, nature's beauty spot. Nestling among the Alps this quaint old Swiss city offers an opportunity to relax and enjoy the invigorating fresh air and Alpine sunshine. Those who wish to climb Mount Rigi or Pilatus will have an opportunity, for others an interesting trip will be made to Zug where recent excavations have been made of a prehistoric village which brought to light a quantity of ancient pottery of a high order.

Paris–June 23 to 27

Arriving this morning in the gay French capitol the day is spent in making the acquaintance of French industrialists interested in ceramics. Léon Yeatman, President of the Ceramic Society and Colonel Bevierre, President of the Master Glassmakers Association of France, have detailed special plant tours for each of the several industrial interests represented in the ceramic tour party.

Visits will be made to Versailles, Malmaison, Fontainbleu, Rheims, and to other places of interest. Every moment of the five days will be used to the best advantage. The final dinner or swan song, will be held the evening of the twenty-sixth when a delightful surprise party will be prepared as a last taste of Gay Paree.

It might be interesting to add that during the stay in Paris the ceramists will attend the annual Technical Congress of the French Ceramic Society. A hospitable welcome awaits them from the Produits Ceramique de France.

Limoges

(A side trip.) An interesting day and one-half can be spent in the Limoges district famed for its china and fine enamel and an enjoyable program is being worked up for those who wish to make this visit from Paris.

Havre or Cherbourg–June 27 to July 5

Leaving Paris the party will board the boat train to the port from whence it sails and begin the homeward bound journey. Once more aboard the Cunarder the time will

be devoted to cementing those associations made abroad. Here will be summed up experiences of the trip; here will be recounted memorable events.

New York–July 5

The journey, more than six thousand miles, will have been covered, and crowded into every hour of our six weeks, experiences that will live long in the memory of all.

The cost of the tour will be $900.00.

Application for membership in the Ceramic Tour Party should be addressed to THE AMERICAN CERAMIC SOCIETY, 2525 N. High St., Columbus, Ohio, or to Executive Tours, 25 Broadway, New York City.

FIG. 1.—Proposed Itinerary for American Ceramic Society European Tour

COLLECTIVE JOURNAL INDEX

This year the members of this SOCIETY are concluding the tenth volume of the *Journal*. Nineteen volumes of annual *Transactions* were published and a Collective Index was issued in 1920 covering these volumes. On recommendation of the Committee on Publications, the Board of Trustees has unanimously approved the issuance in 1928 of a collective index covering the ten volumes of the *Journal*, the six volumes of *Abstracts*, and the six volumes of the *Bulletin*.

Since 1928 is the thirtieth year of activity for the SOCIETY it will be fitting that, together with the Collective Index there shall be a record of the SOCIETY'S activities up to date, a complete membership roster, the official committee personnel record, and a list of publications. Such a year book could well be pointed to as a fitting celebration of the conclusion of thirty years of continued and progressively increasing promotion and correlation of activities in ceramic research and education.

In order that this thirtieth anniversary book will contain all information that the members will need, suggestions are solicited.

NEW MEMBERS RECEIVED FROM MAY 15 TO JUNE 1

CORPORATION

Richard Dudgeon, Inc., New York City, Jas. Moore, representative.

PERSONAL

Laura B. Charman, Sculptor and Potter, Magnolia, N. J.

Yuzo Hashimoto, Plant Manager and Vice Chief Engineer, Shofu Kogyo Co., Kyoto, Japan.

G. W. Heffelfinger, Bricklayer Foreman, Worth Steel Co., Claymont, Del.

***A. R. Heubach,** c/o "Keramig," Ratingen, Germany.

Hugo Spitzer, General Superintendent, Fire Brick Works of the Rothschild Ironworks of Wittkowitz, Czechoslovakia.

D. D. Whitacre, Vice President, Whitacre-Greer Fireproofing Co., Waynesburg, O.

STUDENT

Homer M. Tostlebe, 619–5th St., Ames, Iowa.

Membership Workers' Record

CORPORATION		PERSONAL	
W. F. King	1	E. deF. Curtis	1
		K. H. Endell	1
STUDENT		M. Ichijo	1
D. A. Moulton	1	T. N. Kurtz	1
		W. Keith McAfee	1
*Renewal		Total	5
		Grand Total	7

PERSONAL NOTES OF MEMBERS

Y. R. Anderson has resigned his position with the Evens and Howard Fire Brick Company of St. Louis and is located at Claybank, Sask., with the Dominion Fire Brick and Clay Products, Ltd.

J. F. Blackie of the National Enameling and Stamping Company has been transferred from Milwaukee to St. Louis, Mo.

I. B. Branham gives as his latest address The Batchelder-Wilson Company, 2633 Artesian Street, Los Angeles, Calif.

H. H. Clark, who represents the American Gas Association has moved to Room 2009, 100 West Monroe Street, Chicago, Ill. Mr. Clark is vice president of the United Public Service Company.

The B. F. Drakenfeld and Company, Inc., is located at 45–47 Park Place, New York City, having moved from 50 Murray Street.

H. Forester of the Veritas Firing System Company, Cleveland, Ohio, has transferred to the Easton's Point, Newport, R. I. office of the same Company.

John R. Green formerly of Indianapolis is associated with the Brown Instrument Company of Philadelphia, Pa.

Henry W. Harrington of Lexington, Ky. has moved to Oxford, N. Y.

Wilfrid Mavor has moved from Schenectady, N. Y. to Ottawa, Can., where he is connected with the Ferro Enameling Company of Canada, Ltd.

L. A. Mekler has moved to Chicago, Illinois from Elizabeth, N. J.

Gordon R. Pole is now at the Bureau of Standards, Washington, D. C., National Terra Cotta Society Fellowship. Formerly Mr. Pole assisted in research work at Mellon Institute, Pittsburgh, Pa.

Fred W. Schroeder has moved from Rolla, Mo., where he has been connected with the U. S. Bureau of Mines to Corning, N. Y.

Kenneth M. Smith, who has been teaching ceramics at the East Liverpool High School has moved to Trenton, N. J. where he is now associated with the United Clay Mines Corporation.

Leon Volkmar has moved from Cincinnati, Ohio to Bedford Village, N. Y. His address for the summer will be Ridgefield, Conn., R. F. D. No. 5.

D. C. Wysor is with the General Chemical Company, 40 Rector Street, New York City.

TENTATIVE METHOD FOR COMPLETE SAND ANALYSIS

Glass Division, Standards Committee, American Ceramic Society

NOTE: This method has been approved by the Standards Committee and is now issued to the committee for final perusal and criticism.

Preparation of the Sample

The sample may be a well-mixed unground portion or it may be ground in an agate mortar.

Solution of the Sample

Weigh out a 10-gram sample and place it in a platinum dish of suitable size; 250 cc is recommended. Moisten the sample with water and add 2 cc concentrated sulphuric acid. Fill the platinum dish two-thirds full with concentrated hydrofluoric acid and evaporate on the sand bath, or if so desired on the hot plate with an asbestos board beneath, to a volume of about 50 cc. Examine the contents of the dish and if complete solution of the sample has not taken place add more hydrofluoric acid and evaporate again. When complete solution of the sample has been accomplished evaporate to copious fumes of SO_3, add one or two drops of fuming nitric acid to oxidize any organic matter. Cool the solution, dilute to about 100 cc, filter and transfer any residue left in the platinum dish to the filter. Wash the filter 5 times with hot water, place in a covered platinum crucible, dry and ignite until the filter paper has entirely burned off. Cool the crucible, add about 2 grams of sodium carbonate and fuse over a Meker burner or its equivalent. Cool the crucible and dissolve the melt with dilute hydrochloric acid and hot water in a small beaker. If a residue still remains after this treatment, filter into the main solution and wash four times with hot water. Dry and ignite the filter in a platinum crucible and fuse with one gram of potassium pyrosulphate. Dissolve the melt in dilute hydrochloric acid and hot water and add to the main solution. Evaporate the total solution in a platinum dish, porcelain casserole, or Pyrex beaker to dryness on the water bath. Bake at 110°C for one hour. Cool the dish, add 25 cc dilute hydrochloric acid and allow to stand on the water bath 15 minutes with the dish covered. Add 50 cc of water and allow to stand 5 minutes. Filter the solution and wash 6 times with hot water.

R_2O_3

Heat the filtrate from "Solution of Sample" to boiling, add 2 or 3 drops of methyl red indicator and then dilute ammonium hydroxide drop by drop to a yellow end point. Boil from 1 to 2 minutes and filter immediately. Transfer the contents of the dish or beaker to the filter with hot 2% neutral ammonium chloride and wash 5 times with this solution. Dissolve the precipitate in the minimum amount of hot hydrochloric acid (1–10) receiving the washings in the original beaker in which the precipitation was made. Wash the filter 5 times with hot water. Precipitate again as before with the aid of macerated filter paper if desired to aid in filtering. Transfer the precipitate quantitatively to a filter with hot neutral 2% ammonium chloride or ammonium nitrate and

wash 6 times with either of these solutions. Place the precipitate in a previously ignited and weighed platinum crucible, dry and ignite to constant weight under good oxidizing conditions at 1100°C.

CaO

Combine the filtrates from the two R_2O_3 precipitations, make slightly acid with hydrochloric acid and evaporate to a volume of 150 cc. Add a slight excess of ammonium hydroxide and heat to boiling. Add slowly with constant stirring 10 cc of a 4% solution of ammonium oxalate and boil 5 minutes. Let stand on steam bath for at least 4 hours or over night. Filter and wash with hot 1.5% ammonium oxalate solution 6 times. Place in an ignited and weighed platinum crucible, dry and ignite to constant weight as CaO.

MgO

Make the filtrate from the CaO precipitation slightly acid with HCl, and add ½ gram of diammonium phosphate ($(NH_4)2HPO_4$). Evaporate to 150 cc and cool. Add ammonium hydroxide slowly to a slight excess. Stir vigorously until the magnesium begins to precipitate. After several minutes add (conc.) ammonium hydroxide to make one-ninth by volume. Let stand over night. Filter on a previously ignited and weighed Gooch crucible or on filter paper if desired, wash with 5% by volume ammonium hydroxide 5 times, dry, and ignite gently. Finally ignite to constant weight at 1100°C as $Mg_2P_2O_7$.

Ignition Loss

Ignite 5 grams of sample at 1100°C in an ignited and weighed platinum crucible to constant weight. Report the loss in weight of the sample as ignition loss.

The Determination of Iron as Fe_2O_3

NOTE: This method for determination of iron has already been accepted tentatively by the Glass Division.

Weigh a 10-gram sample of the sand into a platinum dish of 150 cc capacity. (It is not necessary to grind the sand). Moisten the sample with distilled water and add 2 cc concentrated H_2SO_4. Mix thoroughly by shaking the dish. HF (C.P. 48%) is now added until a few drops no longer produce any reaction.

NOTE: This reaction is not violent unless the sand is ground.

Fill the dish with HF, place on the sand bath or hot plate, and evaporate.

The sand becomes flocculent and may completely dissolve. In the latter case, the evaporation is carried to H_2SO_4 fumes, rapidly at first, then carefully to avoid loss by spattering.

In case the solution is not complete carry the evaporation down half-way, then refill the dish with HF, and evaporate to H_2SO_4 fumes and dryness.

Ignite the dish containing the residue for a few minutes at 1800°F to drive off any excess H_2SO_4 and burn out any organic matter that may be present.

Cool the dish containing the residue and add 25 cc HCl 1:1, cover with a watch glass, heat to boiling and filter into a 500 cc Erlenmeyer flask. Wash the filter paper three times with hot H_2O.

Return the paper to the dish and ignite. Make a quick fusion with Na_2CO_3 (2 grams, 5 minutes). Dissolve the melt with HCl 1:1 and add to the Erlenmeyer flask, disregarding any silica that may have been carried over. Add 1:1 HCl (and concentrated HC equal to the volume of wash water used) to bring the volume up to 150–200 cc. Cover with a watch glass and heat to boiling. Cool the neck of the flask with a stream of cold water. Reduce the iron with stannous chloride (minimum number of drops). Adjust the titration head, insert the buret tip, and titrate with standard $K_2Cr_2O_7$ while recording the potential by means of a Roberts Electrometric Titration Apparatus. From

the potential-titration curve ascertain the number of cubic centimeters of $K_2Cr_2O_7$ solution required by the iron chloride in the solution.

Calculate the percentage of total iron as Fe_2O_3. Report as Fe_2O_3. A blank is run on the reagents used and the blank subtracted from the titration.

NOTE: It was found necessary to avoid high results of Fe_2O_3 in U. S. Bureau of Standards glass sand, No. 81 to remove the H_2S metals from acid solution before the $K_2Cr_2O_7$ electrometric titration.

Determination of Titania and Zirconia

Fuse the ignited and weighed R_2O_3 residue with 1–2 g of potassium pyrosulphate and take up the melt in 30 cc of dilute sulphuric acid (1:9).

(A) Determination of Titania Transfer the solution to a Nessler comparison tube, rinse with a very little of the acid, add 3 cc of fresh hydrogen peroxide and dilute with the acid to 50 cc. In another tube dissolve an equal amount of pyrosulphate in the dilute acid, add 3 cc of the peroxide and dilute with acid to the same volume. To the comparison tube add a standard solution of titanium sulphate, $Ti(SO_4)_2$, until the colors in the two tubes are exactly the same when the solutions are thoroughly mixed. The amount of titanium oxide added, divided by the total volume of the solution represents the amount of titania per cc of the unknown solution. This value multiplied by 50 represents the amount of titanium oxide in the sample taken for analysis. It is not likely that a glass sand will contain so much titanium that the color in 50 cc of a solution obtained from a 1 g sample will be too strong for colorimetric comparison.

The standard solution of titanium sulphate can be prepared from titanium oxide of known purity or from potassium titanium fluoride, K_2TiF_6. The former can be fused with potassium pyrosulphate, the melt dissolved in dilute sulphuric acid and the solution diluted to the desired volume with the same acid. If the fluoride is used, purify the salt by crystallization from hot water in platinum and dry the crystals. Treat the calculated weight of the dried crystals with sulphuric acid in platinum, evaporate to fumes, cool the solution, and wash the walls of the vessel with water. Repeat the evaporation and washing twice to make sure that all fluorine is expelled. Cool the solution, prepare a dilute sulphuric acid (1:9) solution of the desired volume, and determine its titre by precipitation with ammonia and final ignition to TiO_2.

(B) Determination of Zirconia To determine zirconia add 5.0 g of diammonium phosphate, $(NH_4)_2HPO_4$, to the solution that was used for the determination of titania and which should still contain hydrogen peroxide and approximately 10% of sulphuric acid by volume. Cover and allow to stand overnight at a temperature of 40 to 50°C. Hydrogen peroxide must be present in excess at all times. If a precipitate appears, filter the solution and wash the paper and precipitate with a cold 5% solution of ammonium nitrate. Dry the paper and precipitate in a weighed platinum crucible, cautiously burn off the carbon, and finally heat at approximately 1000°C. Cool and weigh as ZrP_2O_7 which contains 46.3% of zirconium oxide.

Al_2O_3

Alumina is determined by subtracting from the total R_2O_3 the per cents found for Fe_2O_3, TiO_2, and ZrO_2.

SiO_2

Silica is determined by difference by subtracting the percentages of R_2O_3, CaO, MgO and ignition loss from 100.

Blank

Run a blank using exactly the same amounts of chemicals as in the original analysis. Subtract any impurities found from the amounts found in the analysis of the sand.

INDUSTRIAL CERAMIC ART

The Art Division of this SOCIETY aims to be practical. It also aims to meet issues the best it can. The vision of its Officers and Committee Members is being extended as a result of persistent inquiries and analysis. They are satisfied neither with their efforts, the scope of their activities nor with the assisting advice which has been given by the manufacturers; they know that these have been too meager, narrow, and wanting. It is no fault of the Art Division officers that they have not yet completed a program of activities that will interest alike the ceramic artists and the manufacturing executives.

In the News and Notes section of this *Bulletin* is a report of a courageous and vigorously executed scheme by which the manufacturers and artists in Sweden very successfully applied art to the production of wares on a factory quantity basis. They have demonstrated that art intelligently applied is profitable, and now they are exhibiting in other countries the improved ware they produced.

The Art Division has not been unmindful of the benefits which would accrue from a coördinated program by manufacturers and artists for application of art to factory ceramic ware production. Exhibitions have been made, a library planned, and joint sessions have been held with other Divisions in the SOCIETY; papers and symposiums have been rendered for the purpose of analyzing the situation and exposing the most profitable procedure. While our Art Division has been making these efforts the Swedish manufacturers have boldly put into operation and have accomplished that which our Art Division has been planning for American manufacturers.

But our Art Division activities have been fruitful in many ways, principally in the formulation of plans for collegiate instruction and research in ceramic art and technology. These plans were made adaptable to Ohio State University by the Ohio Ceramic Industries Association and by that Association presented and urged through to adoption. Ohio State University will, next fall, have a department of ceramic art. A well-qualified professor has been employed.

The establishment of this Department of Ceramic Art at Ohio State University supplies the material and the inspirational foundation which the Art Division of this SOCIETY believes to be essential to plant proving of the value of art in ceramic manufacturing. The scheme carried out by the manufacturers of Sweden was more swift and probably more productive of immediate dividend profits than will be the plan formulated and put into being through the agency of the Ohio Ceramic Industries Association. Both schemes, however, are based on coördination of all interested agencies and parties.

Ohio State will provide the laboratory and instructional facilities, and in collaboration with the other universities, the art schools, and the industries, it is expected that American ceramic industries will make the same forward progressive step which the Swedish manufacturers have demonstrated as being very much worth while.

LOCAL SECTION NOTES

Pacific-Northwest Section

The summer meeting of the Pacific-Northwest Clayworker's Association and local Section of the AMERICAN CERAMIC SOCIETY will be held in the vicinity of Portland, Ore., on July 28, 29, and 30. The technical session will be held on Friday, July 29. The program is to consist of a discussion on one general subject of interest to all clay workers, "Comparisons between Clay and Cement Products." The sewer pipe, terra cotta, and brick and tile members will discuss the good and poor features of clay and cement pipe, cast stone, brick and tile respectively. The refractories and pottery industries are the only branches of clayworking which have not felt the cement competition so the topic

will be of interest to practically all of the Pacific-Northwest manufacturers and dealers. Details of the Meeting are being left to the members of the Portland group.

Baltimore-Washington Section Elects Officers

The last meeting of the Baltimore-Washington Section of the SOCIETY was held in Washington at the Ebbitt Hotel on the evening of April 2, 1927.

New officers for this Section were elected for the coming year as follows:

Clarence B. McComas, *Chairman*
R. F. Geller, *Vice Chairman*
R. A. Heindl, *Secretary-Treasurer*
R. R. Fusselbaugh, *Councillor*

A program of motion pictures was presented. (1) A film on the work of the Lenox Pottery, (2) "The Story of a Glass Bottle," provided by the Illinois Glass Company, and (3) "The Story of Fireclay Refractories," obtained from the Bureau of Mines.

Detroit Local Section

Members of the Detroit Section met at the Detroit Engineering Society Clubhouse May 25, 1927.

C. A. Dutton of the Cleveland office of the Carborundum Company of America presented and discussed a four and one-half reel motion picture on the "Manufacture and Application of Silicon-Carbide Refractories."

The meeting was preceded by a dinner at which twenty-four members were present and more than forty members were in attendance at the lecture.

Pittsburgh Section Meets

Donald W. Ross and Ross C. Purdy gave talks respectively on "Glass Industries Refractories" and the proposed "Ceramic Research Institute" at the last regular monthly meeting of the Pittsburgh Section, AMERICAN CERAMIC SOCIETY, Tuesday evening, May 17, 1927.

Mr. Ross gave an illustrated talk on the manufacture and failures of glass tank block refractories and the research that is being done to better their service. (This is presented below.

Mr. Purdy reviewed the purpose and progress of the proposed Ceramic Institute and Research Council. He pointed out that the project would encourage needed fundamental research in the universities which at present is being neglected due to lack of funds and man power. Such a program would bring the American ceramic industry on an equal basis with other industries in research activities. He pointed out where the ceramic industries would benefit directly and are the logical source of support for such a project. Mr. Purdy was enthusiastic over the progress of the work, citing a Fellowship being installed by a group of enamel manufacturers at the University of Illinois. He asked that members of the Section lend their support in promoting good feeling toward the project.

DISCUSSION ON GLASS INDUSTRIES REFRACTORIES

Before Pittsburgh Section, American Ceramic Society

BY DONALD W. ROSS

This number on the program consisted of a brief review of the refractories used in the glass industry, followed by lantern slides to illustrate the points mentioned. The talk was largely a review of the generally accepted principles and contained but little

new material. Glasspot furnaces, particularly the care of the siege was first discussed. This was followed by remarks concerning pots: it was stated that good pots are frequently lost during the heating up, preparatory for use in the furnace.

The arrangement of glass tank plants, various types of tanks and the idea of having a plant unit consisting of two or more small tanks, each equipped with a separate leer, instead of the present practice of using a single large tank were each brought out. Such arrangement allows for greater flexibility, for if one tank or leer is temporarily out of commission it does not necessarily affect the production of the balance of the unit.

Particular attention was drawn to the fact that during heating silica brick crowns for tank furnaces expand and on cooling off again, they contract, but the expansion the first time the crown is heated up (first fire) is frequently greater than it is on the later heatings.

It was noted that in case the silica content of refractories (for use above the metal line) is much greater than that indicated by the formula $Al_2O_3 2SiO_2$, dust arising from the melting batch and settling on these walls causes them to be eaten very smoothly. If the silica content is approximately the same as, or less than indicated by this formula, the silica is washed away by the flux, but much of the alumina of the clay remains behind in the form of large plates of corundum, which gives the surface of such blocks a reddish-brown shiny appearance. Such corundum plates are frequently well developed on the melting side of the cover blocks of the bridge.

The advantage of having no horizontal joints in tank blocks was pointed out and it was shown that horizontal cracks through the blocks behaved the same under glass action as do joints between blocks. Hard fired blocks shrink and crack less on the inner (glass-contacting) surface than do soft porous blocks, with the result that they normally give greater service.

The great prevalency of cracked tank blocks in all tank furnaces indicates how important a matter their resistance to thermal shock is.

Among the slides, several types of bridge walls were shown. The matter of sunken throats was mentioned. Although it may eventually prove that sunken throats are not particularly suited to the manufacture of certain opal and other glasses, such as dark green and black glass, through which radiation is relatively low, sunken throats appear to be quite satisfactory for use in the manufacture of many clear glasses, such as bottle glass.

It appears probable that it is well to have the forebay (entrance to throat) relatively wide along the bridge wall. It may even prove to be desirable to have this forebay several times as wide as the flowhole through the bridge or throat. Sunken throats appear to furnish relatively cool glass to the refining end of the tank, which apparently deploys to all parts of the refining end, avoiding the formation of hot streams in the refining end.

Such gradual upward movement of the glass apparently results in less wear of the tank blocks in the refining end. It may even prove advisable to follow this matter further and to construct tanks in which the top of the flowhole is a foot or more below the floor level of the tank.

AMES CERAMIC ENGINEERS TAKE SWEEPSTAKES

The Department of Ceramic Engineering at Iowa State College, Ames, took sweepstakes over all competitors in the annual parade of floats representing all the departments of the college, May 13, during the "Veishea" or college open house.

Bernard Palissy, his rustic pottery, his work as author, scholar and potter, were illustrated by the float shown in the accompanying photograph.

The float took all the spare time of the forty-five students who are enrolled in the four-year course, for a period of five weeks and cost in material and costume rental over $100. Had this labor been paid for at Campus rates the labor cost would have been over $300.

Lumber, wall board, paint and old newspapers were the raw materials used, though of course plaster molds for the pâpier machè work had to be made by the students to do the work.

It is the intention of the Department to tell the story of the many heroic figures in the history of ceramics by means of these floats, and Palissy is always good material to be used for show purposes.

The float was entirely the production of the engineering students who are not enrolled in any art pottery courses. It might have been better if there had been a lot of the artists working on it but it "brought home the bacon" in competition with two departments that did have artists doing the work. The experiment was interesting because it shows what the ordinary engineering student can do if he puts his mind and back into a job.

None of the faculty did any of the modeling and none of the boys had ever tackled such work before.

The active work of the Student Branch of the AMERICAN CERAMIC SOCIETY at Ames is given much credit for the success the boys have had with this work.

OBITUARY

Charles H. Bryan

Charles H. Bryan, president of the Mercier-Bryan-Larkins Brick Co. of Detroit, and second president of the Common Brick Manufacturers' Association of America, died at his home in Detroit on Wednesday morning, May 23.

Mr. Bryan, who was one of the best known brick manufacturers in the country, was present at the organization meeting of the Common Brick Manufacturers Association. He was elected a director at its first business meeting and remained on the Board until the time of his death. He was President of the Association in 1921, 1922, and 1923, and has been a member of the executive committee at all times.

For years prior to the forming of this Association, Mr. Bryan was active in the affairs of the National Brick Manufacturers Association, and he never has been found wanting when there was work to be done in the interest of his industry. Before the Detroit manufacturers engaged a paid executive as manager of their local association, Mr. Bryan acted as the secretary of the Detroit Brick Manufacturers and Dealers Association.

He was a man of action, enthusiastic in whatever seemed worthy of his attention, and as member, director and executive of the C. B. M. A. he gave unstintingly of his time and effort. During the three years that he was president he visited the headquarters offices in Cleveland frequently, and was in at least weekly and at times daily contact with the office by long distance telephone. Several of the most valuable activities were introduced and furthered by Mr. Bryan.

As presiding officer over business meetings he had few equals. He also was a speaker of unusual talent. His addresses before groups of manufacturers in both the United States and Canada have been inspirations and resulted in renewed hope and interest in the industry.

His passing leaves a place that will be difficult to fill. The hundreds of brick manufacturers, who affectionately knew him as "Charlie" Bryan, and share with his family and his business associates the serious loss, unite in extending sincere and deepest sympathy to those who were nearest to him.

Mr. Bryan was for several years a member of the AMERICAN CERAMIC SOCIETY.

A CORRECTION

H. S. Lucas writes that his attention has been called to certain statements made by R. C. Purdy and reported in document, *Bulletin of the American Ceramic Society*, April, 1927, under "Conference on Ceramic Research." On page 90 the following paragraph appears:

> Mr. Clare, who has been active on the Research Committee of the National Terra Society, will agree that its problem has dragged along because there has not been a full-time disinterested activator on the job. The director how employed by the Government is being pulled on one side by the Bureau and the other side by the industry, and is not an impartial adviser.

This matter was laid before the Executive Committee of the National Terra Cotta Society at its recent meeting in New York, and the Executive Committee voted substantially as follows:

1. That the work of the National Terra Cotta Society's research fellowship established at the Bureau of Standards has been satisfactory, and the Committee is not aware that it has "dragged along" for any cause whatsoever.
2. That the statement that "the director now employed by the Government is being pulled on one side by the Bureau and the other side by the industry" (meaning the National Terra Cotta Society), is not a fact.
3. That the Director has at all times been an impartial adviser.
4. That the foregoing views are believed to be the views of the National Terra Cotta Society.

H. S. LUCAS, President
NATIONAL TERRA COTTA SOCIETY

NOTES AND NEWS

CERAMIC RESEARCH FELLOWSHIPS

The following notices have been received from four ceramic schools in this country detailing the research work which is being carried on in ceramics under fellowships.

University of Washington

At the present time there are three fellowships in operation at the University of Washington. One will need a new man the first of July, 1927; the second will be vacant January 1, 1928 and the third will be vacant April 1, 1928.

Vance Cartwright, one of the fellowship men is working on the general subject of "The Purification of Kaolins and Other Non-Metallics." He has devised and built one spray evaporator and has designed a second larger apparatus for permanent use in the ceramic laboratory. This operates on the same principle as the spray milk driers to produce powdered milk with modifications which have been found necessary for clay slips. Cartwright is likewise studying the hydrogen-ion concentrations necessary for proper settling and dewatering the clay slips after purification. Some very interesting data is being collected on the local kaolins and this work will be continued with some of the Pacific Northwest ochers.

Roland Clark designed and studied the use of a novel type of blunger and purification apparatus for washing the above kaolin materials and an abstract of his work has already been published by the AMERICAN CERAMIC SOCIETY.

Howard Mansur is continuing Henry N. Baumann's work on the testing of local kilns for firing terra cotta, sewer pipe, and other structural wares. His special equipment consists of a four-point Brown temperature recorder, a Brown carbon dioxide electrical recorder, Orsat apparatus for oxygen and carbon monoxide. He will have a very interesting summer at some of the neighboring plants. We do not have the complete equipment such as that used in the Car Holmes by the Bureau of Mines in the East and our equipment must be arranged so that one man can make all the observations.

Other miscellaneous problems which are being conducted by these men include a study of the different colors and methods produced by vapor glazing brick and tile by throwing various chemicals into the fire boxes of kilns; preheating some of our sticky, highly plastic clays; and drying treatments in a laboratory humidity drier, designed and constructed here. The study of scumming and efflorescence produced by mortars is likewise being continued.

HEWITT WILSON

University of Illinois

(1) "Thermal Expansion and Elasticity of Porcelain."

(2) "Aging of Porcelain," a coöperative investigation which has been in progress since 1924. It relates to the study of porcelain for high tension insulators.

(3) "Investigation of Checker Brick Used in Carbureters of Gas Machines." This coöperative investigation was begun in 1924.

(4) "Feldspar." Coöperative investigation with a firm mining and milling this mineral. This appointment covers a period of two years and the investigations will cover the study of the influence of various types of feldspar upon the physical properties of various types of bodies.

(5) "Enamels for Cast Iron." An agreement has been made with a group of nine firms engaged in the manufacture of such ware.

(6) "Enamels for Sheet Metal." A firm engaged in the manufacture of such wares has offered to finance an investigation of this sort. This matter is under consideration, and probably will be approved.

The following research projects are in progress or just completed in the Department of Ceramic Engineering:

(7) "Drying of Clay Wares." This is a coöperative agreement with the National Brick Manufacturers' Association in which laboratory studies as well as plant studies are being made. Good progress has been made in this investigation.

(8) "Slagging of Refractories." This research was undertaken in 1924 and has resulted in the development of a new type of furnace for testing of slagging. Funds have recently been made available by the Special Committee on Boiler Furnace Refractories of the American Society of Mechanical Engineers for its continuation through the next 12 months.

(9) "A Study of Surface Tension and Viscosity Measurement of Certain Glasses." This is a thesis topic of one of the graduate students enrolled in the department.

(10) "Tungstic Trioxide as a Coloring Agent and Opacifier in Glazes." This investigation was completed by a student who was graduated in February.

(11) "Influence of the Composition of RO Members upon the Development of Colored Lead Glazes." This is an investigation which is being conducted by a student as thesis work.

C. W. PARMELEE

Ohio State University

Three fellowships at Ohio State University are coöperative in nature, the Ohio State Engineering Experiment Station and the United States Bureau of Standards each paying one-half of a $750 stipend.

The following fellowships are listed for the coming year although the appointments to these have not yet been approved.

(1) "Study of the New Vitrifying Agents for Whiteware," Department of Mineralogy.

(2) "Study by Radiographs of the Mineral Structure of Ceramic Bodies," Department of Ceramics.

(3) "Critical Study of Slip Control Methods," Department of Physical Chemistry.

The following fellowships (calendar year) may be established in the Engineering Experiment Station and will pay a stipend of $1,000, the following subjects being scheduled for investigation.

(4) "Industrial Application of Slip Control Methods."

(5) "Control of Properties of Dust Pressed Whiteware Bodies."

The last fellowship (6) "Study of Glass Tank Block Corrosion," is a fellowship established for one year by two coöperating companies under the direction of the Department of Ceramic Engineering.

Mr. Harcourt is employed at Roseville as senior investigator at the State Experimental Brick plant, under supervision of the Engineering Experiment Station.

It is understood that while a fellowship may be placed technically in another department there is full coöperation between it and the ceramic department.

A. S. WATTS

Stanford University

During the past two years the major ceramic activity at Stanford University has been the testing of clays from the known deposits of California. The California State Mining Bureau has contributed enough money to cover the actual cost of materials used, and to permit the employment of a part-time student assistant to do much of the routine work. H. J. O'Carroll, a graduate student in metallurgy and ceramics, has held the assistantship during most of the period; all of the testing work will be completed by July 1.

The ceramic laboratory is steadily being equipped, and by next October, enough basic equipment will be available to permit studies in bodies and glazes, and in the properties of finished ceramic products. The University is at all times ready to consider coöperative investigations, if suitable financial and technical arrangements can be made

It is felt that technical education and research cannot flourish without close coöperation with industry, and it is hoped that the ceramic industry of the State will utilize the facilities of the University to the fullest possible extent.

W. F. DIETRICH

UNITED STATES BOARD OF TAX APPEALS ALLOWS CONVENTION EXPENSES DEDUCTED FROM INCOME STATEMENT

Alexander Silverman, Petitioner, v. Commissioner of Internal Revenue, Respondent

Docket No. 10389. Promulgated May 12, 1927

Amounts expended by petitioner, a professor of chemistry and a member of the faculty of the University of Pittsburgh, in connection with the carrying on of his profession, in attending scientific meetings and conventions, constitute an ordinary and necessary business expense.

S. Leo Ruslander, Esq., and A. E. James, Esq., for the petitioner. D. D. Shepard, Esq., for the respondent.

This proceeding results from the determination of a deficiency in income tax for the year 1921 of $55.88 by reason of disallowance of a deduction of $558.75 claimed by petitioner as ordinary and necessary business expense for the taxable year in carrying on his duties as a professor of chemistry and a member of the faculty of the University of Pittsburgh. The facts are found as stipulated.

Findings of Fact

The petitioner is a resident of Pittsburgh, Pa. He keeps his accounts on the basis of actual receipts and disbursements. Prior to and during the year 1921 he was at the head of the Department of Chemistry of the University of Pittsburgh, with the title of Professor of Chemistry, and has for the past twenty-one years been a member of the faculty of that university.

As the head of the department of chemistry, it was expected of and incumbent on him as such to keep abreast in his particular field of work and in touch with other scientists in the same field, which was done among other ways by the preparation and publication of papers, by the reading of technical periodicals and by the attendance at such conventions where consideration of subjects of a scientific nature were presented and discussed.

The petitioner attended like conventions prior to 1921, did so attend in 1921 and has since so attended, such action on his part being expected and necessary, as it was of others similarly employed at the university, for the purpose of keeping thoroughly informed in his field of work and in touch with other scientists, and in order to advance the interests of the university, though his contract of employment does not specifically make mention of any such activities and there was no provision made for repayment to him of expenses so incurred.

In the taxable year mentioned, petitioner for the purposes and objects mentioned, attended the AMERICAN CERAMIC SOCIETY at Columbus, Ohio, the American Chemical Society at Rochester, New York, and a meeting of the same Society in New York City, and, in so doing, incurred and paid reasonable and actual expenses for hotel rooms, meals and railroad fare to and from said conventions, the sum of $558.75, no part of which sum has been repaid him by the University, nor by any person, society or organization, whatever. Each of the three trips mentioned occupied a week and petitioner was in attendance the full length of each convention, and for each convention prepared and delivered a paper or papers. By reason of the fact that petitioner was a member of the council of the American Chemical Society, he was in attendance prior to the general convention seasons.

Opinion

LITTLETON: The Board has held that expenditures of the character and made under circumstances involved in this proceeding are deductible as ordinary and necessary business expense. *M. D. Shutter*, 2 B. T. A. 23. We have also held that expenditures made by a professional cartoonist for periodicals and other current literature and in attending political conventions, when properly proved, were proper deductions as ordinary and necessary business expense. *J. N. Darling*, 4 B. T. A. 449.

The Board is of the opinion from the facts in this proceeding that the petitioner is entitled to the deduction claimed.

Judgment will be entered on 15 days' notice, under Rule 50.

SWEDEN'S SOLUTION OF THE "ART IN INDUSTRY" PROBLEM[1]

The Swedish exhibition of industrial and decorative arts by the Society of Arts and Crafts, which until recently was on view at the Metropolitan Museum, is unanimously conceded the most significant of its kind yet seen in this country. It consisted mainly of objects within the purchasing power of those of average means, but treated with a degree of artistry which is usually associated with the unique and costly. Dr. Gregor Paulssen is responsible for the experiment involved, and its ultimate success. At a luncheon given him by the Museum, to which the Advisory Committee of the Annual exhibition was invited, he explained general policies and the manner of their practical application to Swedish industries.

In common with the United States and European countries generally, Sweden has undergone a demand for increased artistry in the treatment of accessories of life, and has suffered from the prevalent shortage in designers. The demand was urgent, and the protracted method of training the young for many years, with very doubtful results, hardly seemed adequate to the emergency. A bold experiment was consequently tried, which consisted in capitalizing talent and experience in the artistic class for the benefit of industry.

A careful investigation was made into the capabilities and sympathies of the most prominent younger artists, sculptors, and architects; their temperamental qualifications were carefully weighed, together with possible decorative inclinations. The next step was to stimulate interest and secure coöperation by the industrialist. A certain number of progressive manufacturers were each induced to engage an artist selected by the Society for a period of six months, with the understanding that the latter should have free access to all departments, be supplied with any necessary information, have authority to conduct experiments and suggest modifications affecting manipulation in decorative treatment. These artists operated in the joint capacities of student of technique, general observer, adviser and designer, with full liberty to direct their energies when and where they thought best.

This plan was essayed in the pottery, textile, metal, furniture and other artistic industries with signal success; in many cases the artistic level of the industry has been astoundingly elevated, and forms of treatment have evolved which diverge from craft tradition.

The idea of employing and training artists is simple and logical; only the manner in which they are selected and brought into contact with industries involves complication. Many instances can be referred to, in which an ambitious industrialist has engaged a distinguished artist to establish a higher level in treatment. With the natural tendency for depreciating importance in the familiar, the manufacturer has overlooked or ignored the

[1] *Architectural Record*, pp. 375-76, April, 1927.

vital part which manipulative procedure has always played in decorative expression. He tells the utterly confused artist not to bother with questions of feasibility, and to trust to the factory to carry out all his ideas. That same manufacturer, however, is far too practical to engage a horticulturalist to improve his mechanical equipment; evidently he does not realise that he is just as indirect when he asks an artist to improve the standard in production without acquainting him first with the intricacies of process, and with the resistance of different substances to manipulation. It is precisely this initial recognition of technical control in artistic expression that is responsible for success in the Swedish movement.

From the point of view of economy of time in training, the selection of individuals of matured temperament, trained observation, and skill in artistic expression, is all so much to the good: if the individual proves unadaptable to decorative activities, this condition is discovered at a very early date, and another artist takes his place.

The Society recognized the futility of creating fine models for reproduction in mass, if uneducated and unsympathetic individuals are allowed to supervise the various stages of manufacture. To meet this condition, art schools were included in the movement, with a complete change in objective. The curriculum consists of general instruction in drawing and designing, planned to as to qualify the majority as factory supervisors. Students of superior ability have specialized instruction to train them as professional designers for various crafts.

Those who have suffered in seeing the ruthless massacre of promising decoration when handled by factory talent, will appreciate the enormous difference which such a revision in factory procedure would mean to our industrial arts. If the administrator could be found, Sweden has supplied us with the first practical solution of a most intricate industrial problem.

There is a tendency in the artist of today to look with less contempt on the decorative arts and industries: this may be the result of high prices paid for advertising drawing or posters for national publicity. Insofar as the material stimulus is concerned, there are many industries which might be as financially interesting as advertising, with greater promise of permanent contact; but the artist must grasp the fact that considerable effort is involved in mental equipment for adaptability and that there is nothing derogatory in creating beautiful objects for human enjoyment and environment.

In America we are just waking up to what these things mean to behaviour and citizenship, and the attainment of difficult objectives imparts a spirit of sportsmanship to the invention of ways and means. If we judge racial temperament by the proverbs and maxims of a country, we think Sweden has an advantage over us in our respective attitudes to aesthetic development and sympathy with beautiful accessories of life. There is a Swedish maxim which runs somewhat after this fasion: A man should provide for his table on a scale below his means; he should dress in accordance therewith, but he should equip his home on a more ambitious level. LEON V. SOLON

SOCIETY OF GLASS TECHNOLOGY

April Meeting

The Tenth Annual General Meeting of the Society of Glass Technology was held in Sheffield April 27, 1927. Walter Butterworth was reëlected President and among the other officers elected were:

J. Connolly, *General Honorary Treasurer*
F. C. Flint, *American Honorary Treasurer*
W. E. S. Turner, *Honorary Secretary*

A discussion on furnace efficiency was inaugurated by W. E. S. Turner, in a paper entitled "A Brief Review of Furnace Developments."

Prof. Turner stated that his intention was to survey the present position of furnace practice in this country and abroad as the basis for considering possible lines of advancement in the future.

Dealing with the operation of pot furnaces in this country data were given of numerous furnaces engaged upon various types of work, some of the observations dating back to 1916. It is evident from the figures that (*a*) a saving in fuel was obtained by the newer types of recuperative or regenerative furnaces, (*b*) heavy expense is incurred by the practice of founding only once a week, and (*c*) the fuel consumption is greatly increased when the eye of the furnace had worn big. The efficiency of modern British pot furnaces compares favorably with those of Germany.

Among the improvements effected during the last few years in furnace design were (1) greater compactness, (2) better utilization of waste heat, (3) the introduction of tangential burners, and (4) sillimanite sieges. The type of ware made greatly affects the efficiency, while mutual consideration of the problem by masters and men of methods of working should result in greater output at less cost.

Passing to the consideration of tank furnaces, Prof. Turner gave data of numerous tanks working for hand operation, for semi-automatic bottle machines, for mixed automatic and semi-automatic machines, and for fully automatic machines. Very few data were available relative to Continental practice, but from figures quoted by H. Maurach in 1925 the results obtained in Germany are probably not as good as those reached in this country. Speaking generally, tank furnace practice on the Continent has not reached the British attainment, which is now equal to anything yet achieved in America.

The main sources of economy with a view to increasing efficiency were indicated. Among the problems which still required more thorough examination were: (*a*) design of ports; end ports in some cases appeared to give longer life to tank blocks, (*b*) bridges, the form of the basin and whether there should be one or two dog-houses, (*c*) depth of the refining end of the tank, whether it should be less than at the melting end, (*d*) utilization of waste heat, and, (*e*) increased insulation in various parts of the furnace, crown, side walls, etc.

In conclusion Prof. Turner referred to a suggestion made by B. P. Dudding that it would be a good thing to see how far it was possible by a national exchange of information to develop furnace operation to a fuller stage. The Department of Glass Technology of Sheffield University recognizes the importance of the problem and several series of systematic measurements have already been carried out by members of the staff, at the request of some manufacturers. Work on these lines has been carried out in Germany since 1920, when an institution was set up to study the problems of furnaces and fuel in the glass industry. Similar systematic furnace measurements are needed in England since the sound lines for real progress must rest on measured data.

May Meeting

The following three papers were presented at this Meeting of the Society of Glass Technology on May 18.

(1) "The Decomposition of Glass by Water at High Temperatures and Pressures," by G. W. Morey and N. L. Bowen. The glasses were heated with water in steel bombs for about 20 hours. The bomb was then cooled and the product examined. In the case of optical glasses it was found that the barium glasses presented a consistent picture. The amount of attack was greatest with a light barium crown, and least with the very dense barium crowns which were remarkably resistant. The lead glasses as a whole showed a consistent and interesting relation between composition and resistivity. With

small PbO content, as in the "soft crowns" or extra light flints, the glasses were badly decomposed at 300°C and practically complete at 550°. As the lead content was increased, the glasses rapidly improved, the extra dense flints showing remarkable resistance toward water. Of all the glasses tested, a high lead glass was the most resistant to the action of water under the extreme conditions tested.

In addition to the optical glasses, a number of commercial glasses, in the form of pieces of tubing, were subjected to a similar treatment, at the same temperatures. Jena combustion tubing withstood the action of water best, while the failure of Pyrex glass was outstanding. At lower temperatures the Pyrex was exceedingly good, but at the higher temperatures of the experiments the boric oxide was completely extracted. The crystals obtained by Pyrex glass at 325° were unknown but were of particular interest, and their composition is being studied.

(2) "The Brittleness of Opal Glass," G. Gehlhoff and M. Thomas. For the determination of the impact strength a special apparatus was described and Winkelmann and Schott's method was modified by using pressed balls instead of ground and polished cubes. A dense opal glass containing much fluoride was used, the opacity being increased by the addition of zinc oxide. It was found that at a temperature of about 1040°C some discontinuous changes took place, possibly explainable in the following way. At high temperatures the opal glass was clear. In cooling down, crystals of a uniform and small size of grain were precipitated. The glass kept below the devitrification temperature already contained (owing to its having stood longer) bigger crystals. On further cooling down in conformity with the law of the yet undefined constitution diagram, small crystals were precipitated, whereas the existing big ones still grew. It might appear feasible that the opal-glass, containing only crystals of a uniform and small size, possessed greater mechanical strength than a glass consisting of crystals of various sizes, particularly larger ones. The investigation showed that opal glasses must necessarily be worked above the temperature where precipitation of crystals caused opacity of the glass: brittleness resulted if they were worked below that temperature. It was suspected (from work being done) that similar phenomena held good in respect of clear glass.

(3) "The New British 15-Arm Automatic Suction Bottle Machine," by Francis Redfern, Jr. This machine is composed of 15 separate bottle-making units, each complete in itself. All the important bearings on the machine are Timken Roller Bearings or ball bearings, totally inclosed and dirt proof. There are approximately 40 tons of moving parts mounted on the stationary element and the whole machine weighs about 60 tons. It will revolve up to speeds of between 6 and 7 revolutions a minute, and is electrically controlled. By means of an electromagnetic brake automatically applied it can be brought to rest from a speed of 6 revolutions a minute within 2½ feet. To accommodate the machine to the level of the pot, or the glass in it, it is raised or lowered by a small motor which is cut out automatically at the highest and lowest positions. At 6 revolutions a minute, the machine takes about 11½ horse power to revolve it. The machine is constructed in such a way that it is possible to sit inside it while it works. The range in length of bottles (measured from the bottom to the parting line below the ring) which can be manufactured on the machine is from 15 inches to 2½ inches, for a maximum diameter of blow mold of 9 inches and of parison molds of 7 inches. Wide mouth ware can be made in which the maximum outside diameter of the neck mold is 5¼ inches, and the maximum length of plunger which can be inserted into the bottle is 2⅞ inches. A week's production of merchantable reputed quart bottles is estimated at 2800 gross.

The machine can be produced in three sizes, 6, 10, and 15 units. For bottle makers whose trade is of a miscellaneous character, it is claimed that a machine of this design would be ideal. It was possible to make on it, at one and the same time, 6 different bottles all of different shapes, varying in height within a difference of 3½ inches. Bottles varying in weight by 4 ounces have been made on a 10-arm machine.

The meeting on the afternoon of May 19 was devoted to a discussion of furnace efficiency. The discussion was opened by W. E. S. Turner who gave a résumé of his paper on "A Brief Review of Furnace Developments."

B. P. Dudding and E. A. Coad-Pryor suggested that the discussion be focussed under the following headings: (*a*) load-fuel consumption, (*b*) age of tank, (*c*) load and effect on total life, (*d*) maximum efficient load, (*e*) composition of the glass, (*f*) external conditions of all kinds such as contour of neighbouring county, prevailing wind, etc., (*g*) general design: ports, bridges, melting areas, etc. At the suggestion of J. H. Webster a further heading was added, namely, (*h*) the method of control of gas and air.

J. H. Webster observed that too many pot furnaces and tanks suffered from insufficient control. It is quite a common thing to find neither gas nor air control. The question of the number of dog holes was under consideration. He had seen tanks with as many as four and the introduction of four was an easy proportion and could assist in overcoming those imaginary currents which were said to be set up in tanks having one dog hole. With regard to heat losses these were discovered at three important places, (1) producer, 17% (2) furnace structure, 40%, and (3) chimney flues, 28%. Fifteen per cent seemed to be the best figure obtained for heat utilized in actual practice. Reference was also made to waste heat boilers and to powdered fuel.

CALENDAR OF CONVENTIONS

Amer. Assn. for the Advancement of Science	Dec. 28–31, 1927	Nashville, Tenn.
Amer. Assn. Flint and Lime Glass Mfgrs.	July 18, 1927	Atlantic City, N. J.
AMERICAN CERAMIC SOCIETY Annual Meeting	Feb. 5–11, 1928	Atlantic City, N. J.
American Chemical Society	Sept. 5–10, 1927	Detroit, Mich.
American Concrete Institute	Feb. 28–Mar. 1, 1928	Philadelphia, Pa.
Amer. Electrochemical Soc.	Sept. 4–20, 1927	Trip through Northwest
American Engineering Council	January, 1928	Washington, D. C.
Amer. Gas Association	Oct. 10, 1927	Chicago, Ill.
Amer. Inst. Mining and Met. Engrs.	February, 1928	New York City
Amer. Mining Congress	1st week Dec. 1927	Washington, D. C.
Amer. Soc. Mechanical Engrs.	Dec. 5–8, 1927	New York City
Amer. Soc. Steel Treating	Sept. 19–23, 1927	Detroit, Mich.
Assn. Chem. Equipment Mfgrs.	Sept., 1927	New York City
Ceramic Soc. of England	Sept. 26–27, 1927	Bournemouth, England.
Exposition of Chem. Industries	Sept. 26–Oct. 1, 1927	New York City
Hollow Building Tile Assn.	February, 1928	Chicago, Ill.
Natl. Assn. of Mfgrs.	Oct. 25–27, 1927	Chattanooga, Tenn.
Natl. Academy of Sciences	Oct. 18–20, 1927	Urbana, Ill.
Natl. Assn. of Mfgrs. of Pressed and Blown Glassware	July 18, 1927	Atlantic City, N. J.
Natl. Exposition of Power and Mech. Engineering	Dec. 5–10, 1927	New York City
Natl. Safety Council	Sept. 26–30, 1927	Chicago, Ill.
Optical Society of America	Oct. 20–22, 1927	Shenectady, N. Y.

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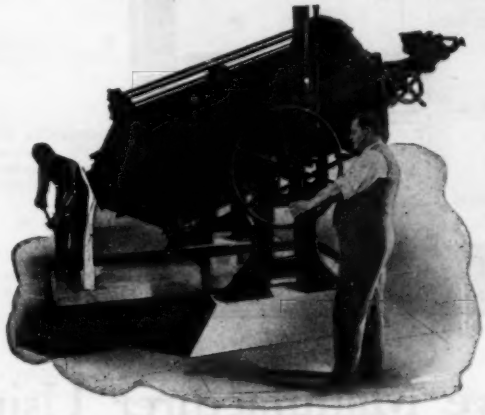

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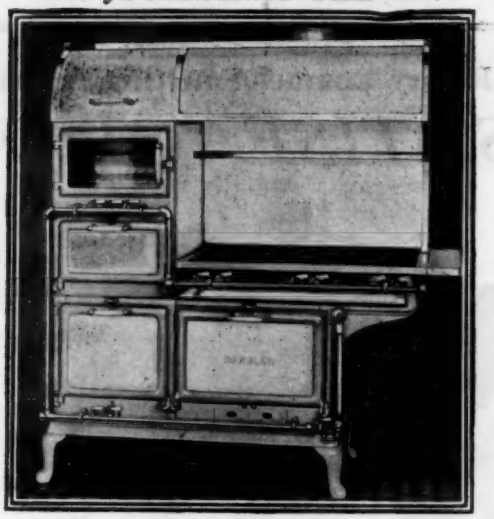

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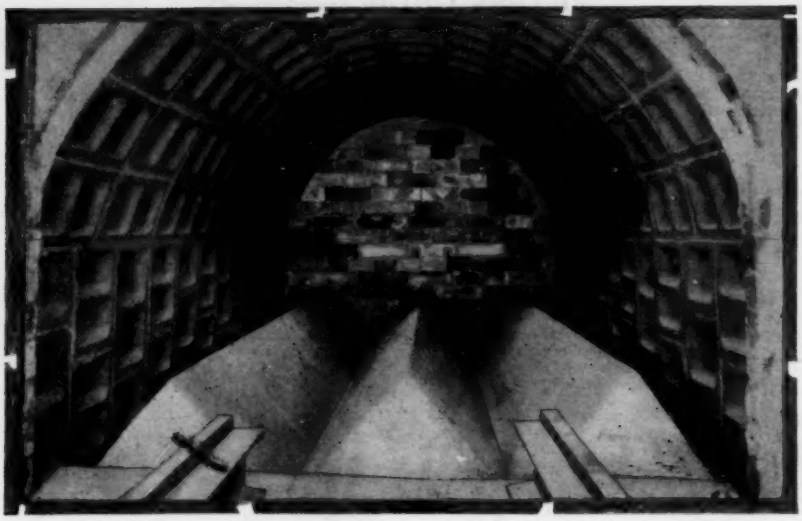

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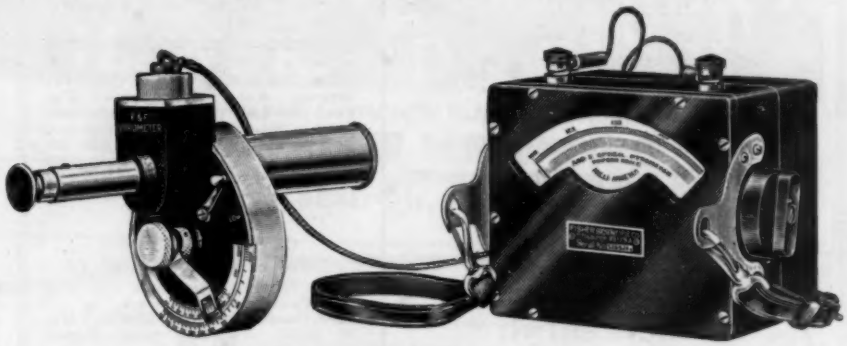

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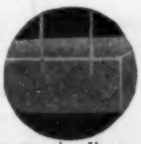
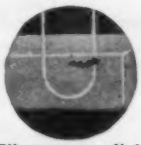


Correct—tip disappears



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The Republic Flow Meters Co., 2240 Diversey Parkway, Chicago, Ill., have issued bulletin CO-34 dealing with flue gas analysis which should be in every ceramic engineer's office.

CERAMIC BREVITIES

The Leeds & Northrup Co., 2901 Stenton Ave., Philadelphia, Pa., have just had revised and expanded, catalog No. 20 on galvanometers. This catalog now embraces the entire line of L & N galvanometers and is complete in every detail.

CATALOG NO. 26— NEWARK WIRE CLOTH CO.

The Newark Wire Cloth Co., 351-365 Verona Ave., Newark, N. J., have issued their new catalog, No. 26, which supersedes their former catalog No. 25.

The new catalog includes complete information with list prices on double crimped heavy steel wire screens; regular coal screens; steel wire cloth; bran duster grade of cloth; tinned mill screen cloth; brass, copper and bronze wire cloth; phosphor bronze wire cloth; Newark metallic filter cloth; monel metal wire cloth; testing sieves; foundry riddles; dipping baskets; and renewable bottom sieves.

Several pages are devoted to tables and many photographs are shown to illustrate the multiplicity of weaves, spaces, and combinations used in the manufacture of wire cloth. The largest space listed is 4" x 4" and the finest is a twilled weave 325 meshes to the inch, the diameter of the wire being .0014 inch and the opening .0017 inch.

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Catalog No. 435 just issued by the Jeffrey Mfg. Co., Columbus, Ohio, shows the wide range and application of Jeffrey wood and steel apron conveyors in handling both bulk and package materials. This equipment is rapidly finding its place in every line of manufacture. The catalog is very complete in description, photographs and dimensions of numerous installations.

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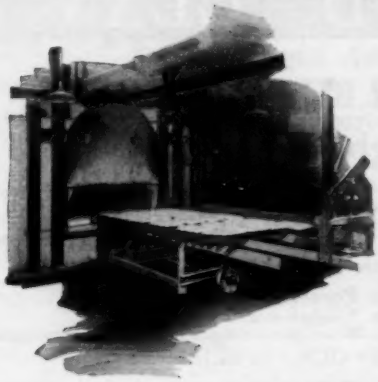

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Journals Urgently Needed

The June, 1923, January, February, 1924, January, 1925, and January, 1926, issues of the Journal are also out of print; 60 cents will be paid for each copy.

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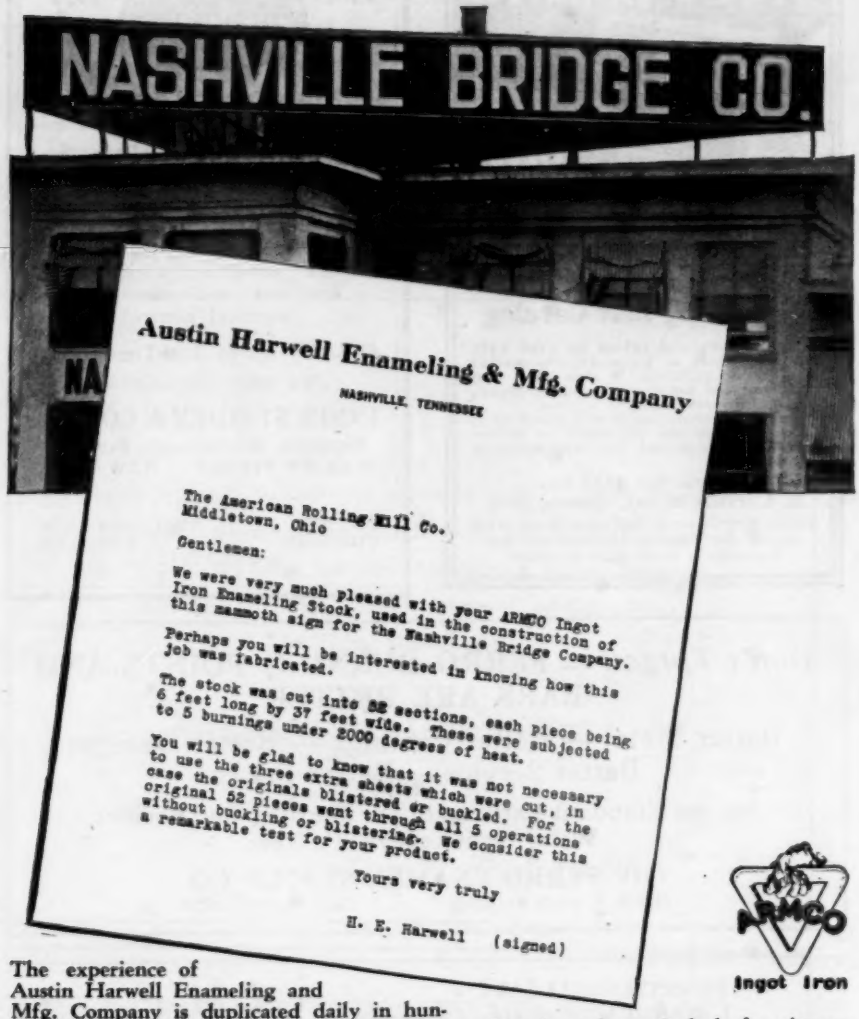
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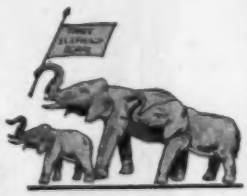

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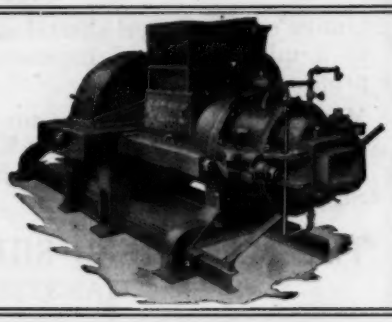

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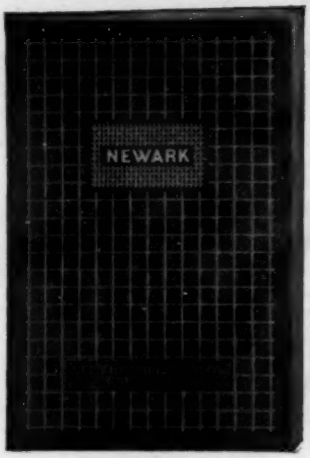

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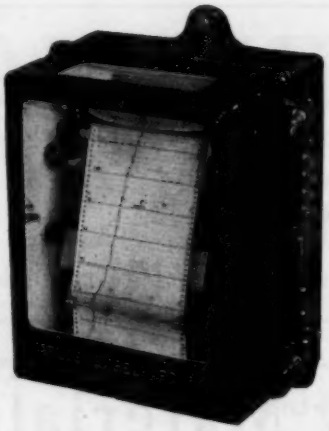

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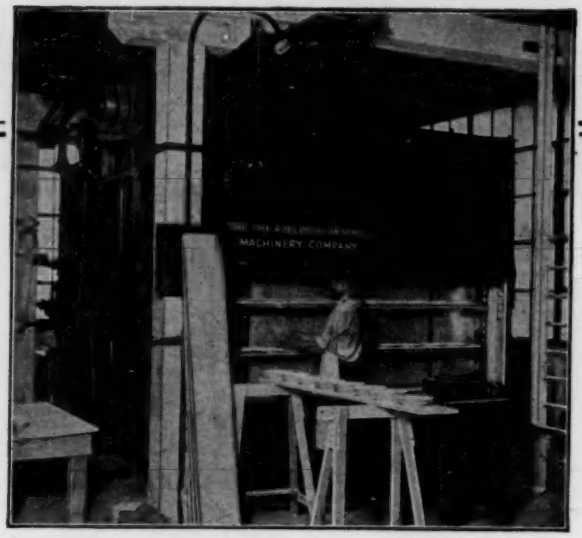

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